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MODULAR AIR DEFENSE EFFECTIVENESS MODEL, PROGRAM DOCUMENTATION AND USER'S GUIDE

Volume I—MADEM Analyst Manual

The BDM Corporation
7915 Jones Branch Drive
McLean, Virginia 22102

31 January 1980

Final Report for Period 1 March 1979—31 January 1980

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This document is one of three volumes which provide documentation and user guidelines for the Modular Air Defense Effectiveness Model (MADEM). The three volumes are: VOLUME I—MADEM Analyst Manual; VOLUME II—MADEM Programmer Manual; and VOLUME III—MADEM Enhancement Specifications.

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PREFACE

The purpose of this manual is to document the Modular Air Defense Model (MADEM) and its implementation. The manual discusses the processes modeled, their structure and relationships, and the various assumptions made. A detailed explanation of the inputs, outputs, and computer processing requirements of the simulation is presented with a complete example case.

The manual is intended for use by analysts examining questions of command, control, and operations in air defense. Its companion volume, the MADEM Programmer Manual, details the actual software which makes up the simulation and is intended for use by programmers.

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SECTION I

INTRODUCTION

The purpose of this manual is to document the Modular Air Defense Model (MADEM) simulation. It is designed for use by analysts who wish to use MADEM in a study. Programmers charged with maintaining or modifying the MADEM software are referred to the MADEM Programmer Manual.

Chapter II of this manual contains an executive summary of MADEM chief characteristics. An overview of the MADEM System is provided in Chapter III. It is intended as a quick reference to MADEM's general capabilities and limitations.

Chapter IV contains detailed documentation of the processes modeled in MADEM. It is followed by a detailed discussion of MADEM operation with emphasis on specific input requirements in Chapter V. An example case, including all inputs and required Job Control Language is provided in Chapter VI.

SECTION II
EXECUTIVE SUMMARY

A. PURPOSE, SCOPE, AND METHODOLOGY

The Modular Air Defense Effectiveness Model (MADEM) was developed by the BDM Corporation to support a Defense Nuclear Agency (DNA) evaluation of the role of nuclear weapons in NATO air defense. MADEM encompasses the entire NATO (Blue) air defense structure including generation of a systematic theaterwide Warsaw Pact (Red) attack plan. Figure II-1 illustrates the scope of MADEM.

MADEM has several unique characteristics which distinguish it from other Theater Level Air Defense Models. Most significant among these is the use of a player-centered design in which key units and flights in the air defense system are explicitly modeled. This approach also allows modeling of individual unit perceptions based on the information that would be available to the unit in a similar real world situation. In addition to explicit unit modeling, MADEM also uses a list processing data storage system to explicitly represent the command, control and communications networks which link units in the air defense system. These explicit representations of air defense system elements are combined with a hex based coordinate system which allows maximum unit movement flexibility with minimal data storage requirements. The result is a flexible model capable of representing a variety of combat processes. Table II-1 summarizes the major processes modeled in MADEM.

While MADEM does extend many modeling aspects beyond what had been previously achieved and does contain some unique characteristics, it is like other models in that it must be used as a relative rather than an absolute tool. Results generated by MADEM should be used only in this context.

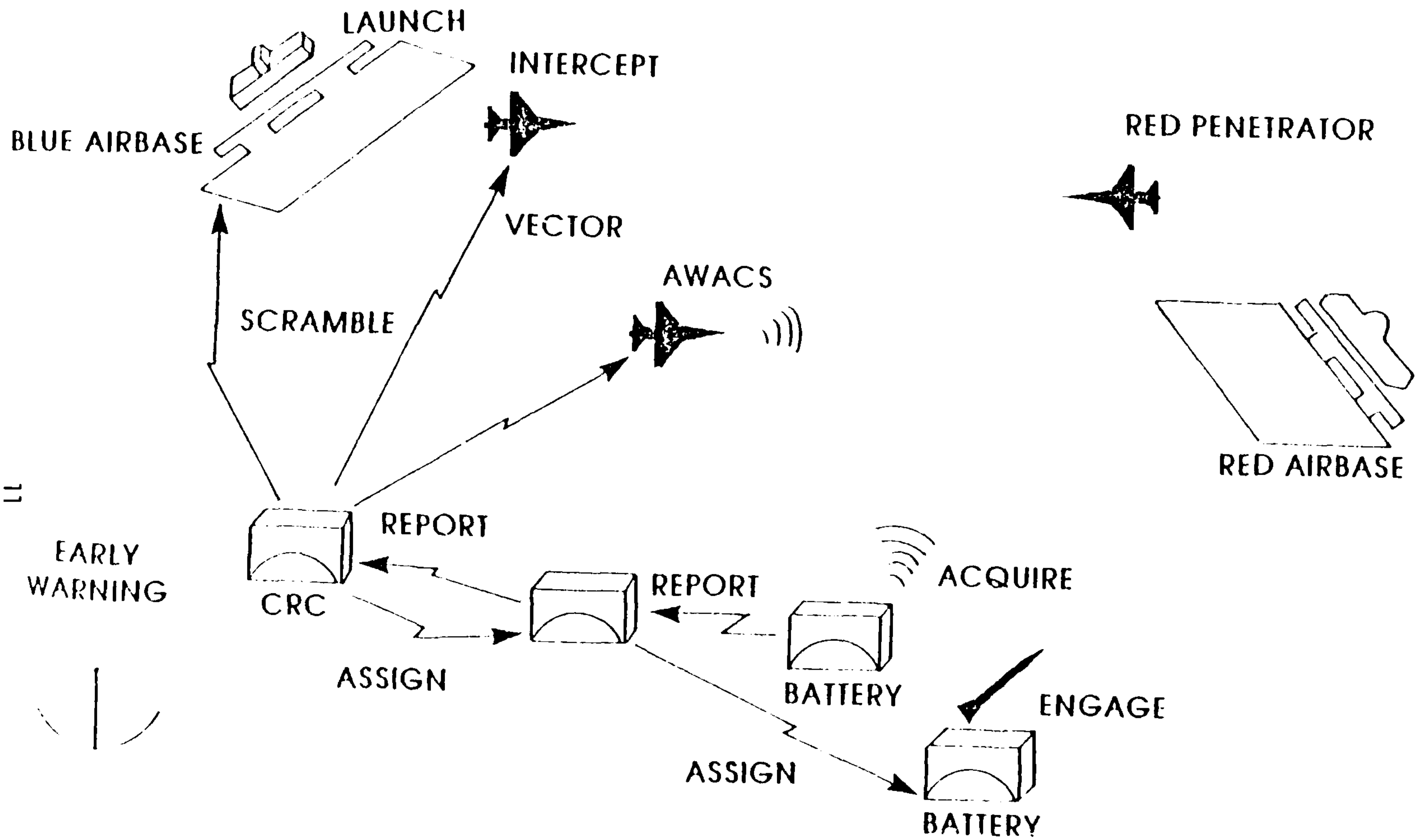

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Figure II-1. Scope of MADEM

TABLE II-1. PROCESSES MODELED

PROCESSES	LEVEL OF DETAIL
PLANNING OF AIR ATTACK BY PACT	MULTIPLE RAIDS AGAINST SPECIFIC TARGETS BASED ON STRATEGIC/TACTICAL CHARACTERISTICS OF BATTLE, AIRCRAFT AND TARGETS
ALLOCATION/ASSIGNMENT OF PACT PENETRATORS	CRC/BOC/BTRY/INTERCEPTOR INTERACTIONS AND AUTONOMOUS OPERATIONS PLAYED EXPLICITLY
AIRCRAFT INITIATED COMBAT	AIR-TO-AIR COMBAT AND AIR-TO-GROUND ATTACK EFFECTS BETWEEN INDIVIDUAL FLIGHTS ASSESSED
GROUND-TO-AIR COMBAT	EFFECTS OF INDIVIDUAL MISSILE FLYOUTS FROM SPECIFIC FIRE UNITS AGAINST SPECIFIC AIRCRAFT ASSESSED
C^3	EFFECTS OF NUCLEAR WEAPONS/ ACQUISITION CHARACTERISTICS/ /IFF/EARLY WARNING COMMUNICATIONS DELAY

B. DATA BASE DESCRIPTION

The data base size depends on the situation to be modelled. The aircraft modeling characteristics are described, as well as how flights and formations are formed. Flight profiles, the numbers of aircraft on different air bases and system characteristics of the different air defense systems are also specified. Probability of acquisition, detection and of kills for the different system are described in the data base. MADEM also has an input language for the specific scenario description. The command structure and unit location as well as the general orders for the Red attack are described in English-like sentences for user ease. Figure II-2 shows a typical input language file entry.

C. PRIMARY OUTPUTS

MADEM is a discrete event simulation. A complete event trace is available for all significant events. A "history" file is also generated during the course of the simulation. This file can be used as input to a post processor which recovers relevant statistical information in tabular form. At present, records are kept on system acquisition, engagements, kills, missiles fired, number of penetrators reaching target, and damage levels for key units.

D. APPLICATIONS

Subsequent to its development, MADEM has been successfully used to evaluate the performance of alternate threat forces and air defense force capabilities in support of study efforts, and to compare and evaluate the sensitivity of various assumptions about system performance capabilities on overall theater air defense effectiveness. Table II-2 summarizes MADEM's potential application areas.

USER INPUTS GENERAL ALLOCATION SCHEME TO MODEL. PLANNING FUNCTIONS IN THE MODEL ASSIGN SPECIFIC AIRCRAFT TO HIT THE TARGET, AND CALCULATES THE FLIGHT PLAN.

USER INPUT EXAMPLE:

RAID 1.

CORRIDOR 1 LIMITS ARE 50.25 LAT 12.0 LONG, 50.33 LAT 11.64 LONG

CORRIDOR 1 DEPTH IS 70 KM HEADING 245 DEG, SPREAD ANGLE 60 DEG.

BUFFER ZONE WIDTH IS 40 KM.

WAVE 1 START TIME IS 0430 HRS DAY 1 FOR 5 MIN.

TARGET TYPE HAWK BTRYS, 1 FORMATION, 150, 0KM RANGE LIMITS

2 TYPE 3 FORMATIONS

Figure II-2. Typical Input Language File Entry

TABLE II-2. MADEM APPLICATION AREAS

- EFFECTS C^3 STRUCTURES AND TECHNOLOGIES ON OVERALL CONFLICT OUTCOME
- EFFECTS OF IMPROVED TECHNOLOGY IN WEAPONRY AND ACQUISITION/IDENTIFICATION SYSTEMS OF BOTH AIRCRAFT AND SAM UNITS
- EXAMINATION OF POLICY AND DOCTRINE REGARDING DEPLOYMENT AND TACTICAL OPERATION OF AIR DEFENSE UNITS FOR BOTH BLUE AND RED
- ROLE AND EFFECTS OF LOGISTICS ON THE AIR DEFENSE POSTURE DURING A SUSTAINED CONFLICT
- ROLE OF NUCLEAR WEAPONS IN AN AIR DEFENSE/AIR DEFENSE SUPPRESSION ROLE

E. OPERATING ENVIRONMENT

MADEM was developed on the Cyber 176 computer at the Air Force Weapons Laboratory (AFWL). It is coded in CDC extended FORTRAN and Compass. In its present form MADEM can be run on the CDC 6600, CDC 7600 and Cyber 176 computers using the FORTRAN compiler.

MADEM contains 22,500 FORTRAN source lines with 280 subroutines. The 131,000 word data storage area requires large core or extended core storage.

SECTION III
OVERVIEW OF THE MADEM SYSTEM

A. INTRODUCTION

The purpose of this chapter is to introduce the reader to the basic architecture of MADEM and the major processes modeled. Both the architecture and processes modeled are documented in greater detail in Chapter III.

B. MODEL ARCHITECTURE

1. MADEM Players

Active players modeled in MADEM include Control and Reporting Centers (CRC), airbases, Battalion Operation Centers (BOC), fire units, and Aircraft Warning and Control Systems (AWACS) as well as the Warsaw Pact flights and formations. Non-players include targets such as Special Ammunition Supply Points (SASP), nuclear surface-to-surface delivery units, and command posts. Players are capable of acquiring and retaining perceptions of their environment and making decisions based on a given logic structure. By communicating with one another within the command structure, players are capable of generating the necessary stimuli to sustain a continuing series of coordinated activities.

2. Geographical Accounting

MADEM uses a hexagonal coordinate structure for geographical accounting. This permits greater efficienty and flexibility for movement. The topological character of hexagons coupled with a unique numbering system permits varying levels of detail. The smallest hexagon used in MADEM is 9.45 kilometers wide. Seven such hexagons form a larger 25.0 kilometer hexagon. Other hexagon sizes are available but not used in MADEM. Reference Figure III-1.

3. Actions Based on Perceptions

MADEM is a player centered model. All processes simulated in the model are initiated by actions taken by player units. Players initiate

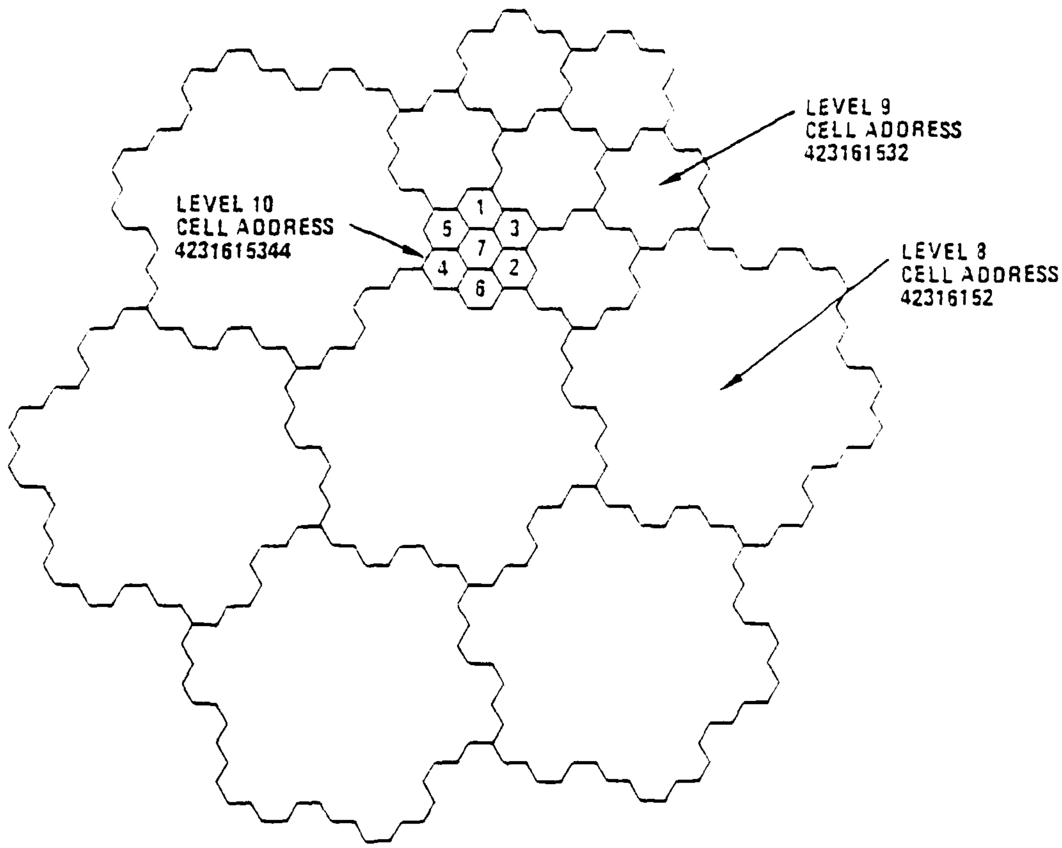

Figure III-1. Example of Hexagonal Structure

actions based on perceptions of the environment received through their acquisition and communications devices. The nature and status of the units' acquisition and communications devices will determine the extent to which perceptual data is distorted. For example, it is possible for interceptors to incorrectly identify a Blue flight as a Red flight and fire on it.

4. Modularity

The model was developed along functional lines so that each major function exists as semi-independent section of the model. Each major function is referred to as a module. The modules are further divided into smaller segments each of which contains the logic for a single decision or physical operation. The modules are tied together through a centralized software control system that manages the overall functioning of the model. This multi-module configuration is illustrated in Figure III-2.

The modularity of MADEM simplifies the process of adding new modules or modifying existing modules. Each can be accomplished with a minimum amount of effort since all modules are linked both operationally and functionally through the simulation control software.

5. MADEM Capabilities and Constraints

Besides modeling the fundamental air defense functions of acquisition, identification, assignment, engagement and analysis, MADEM is able to plan raids. It accomplishes this by matching available resources against a given target base. Following a raid, MADEM assesses perceived damage to the target base and the known attrition of threat aircraft and schedules the next raid. This process is repeated as often as desired without interruption of a production run.

The number of events and variety of activities that can be realistically expected to occur in a large scenario in a short time frame is significantly large. For instance, a typical MADEM historical file contains over 80 events printed for each second of battle (during intense periods). For each event printed, three or more events occur but are not printed.

Since most real life activities can not be precisely modeled or predicted, one should treat the absolute output parameters of MADEM with

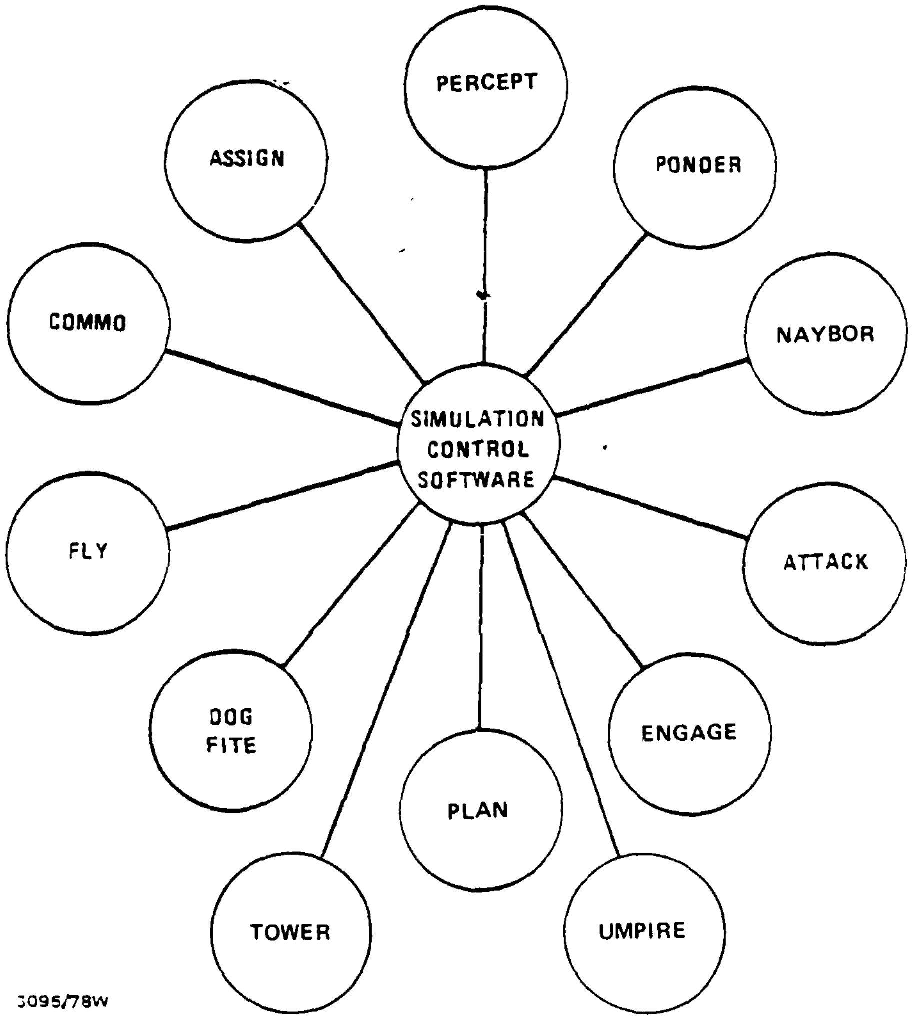

Figure III-2. Example of Modular Construction

caution. They may or may not represent precise outcomes of given scenarios. The principal value of MADEM lies in its ability to fairly approximate a given situation for comparison and relative analysis of scenario variations.

C. MAJOR PROCESSES MODELED

1. Red Threat Planning

a. Primary Input Data

(1) Warsaw Pact air base locations,

(2) Number and type of aircraft available at each air base (basing),

(3) Command structure for scheduling and rescheduling raids,

(4) Corridor locations and characteristics,

(5) Aircraft speed, altitude, and combat radius,

(6) Wave start times and durations,

(7) Flight types and formation descriptions,

(8) Strike criteria for target types by wave and raid

b. Red Threat Planning Capabilities

MADEM plans each wave and raid by matching formation and targeting requirements with basing and corridor information. Subsequent raids are based upon Warsaw Pact aircraft attrition, new targeting requirements, and perceptions of damage caused by previous raids. Figure III-3 illustrates this scenario.

MADEM moves aircraft "flights". Each flight consists of a grouping of homogeneous type aircraft scheduled against a preselected target (targeting planned by MADEM). A "type flight" consists of a specified number of aircraft, depending on the type target it is designed to attack. Individual aircraft are not tracked, but are accounted for when the flight is attacked and aircraft kills result.

An aggregation of flights constitutes a formation (Figure III-4), formations constitute waves, and waves constitute raids. MADEM completes two raids in a single iteration by assessing the previous raid and planning the subsequent raid. Separate iterations may be run for each air defense alternative.

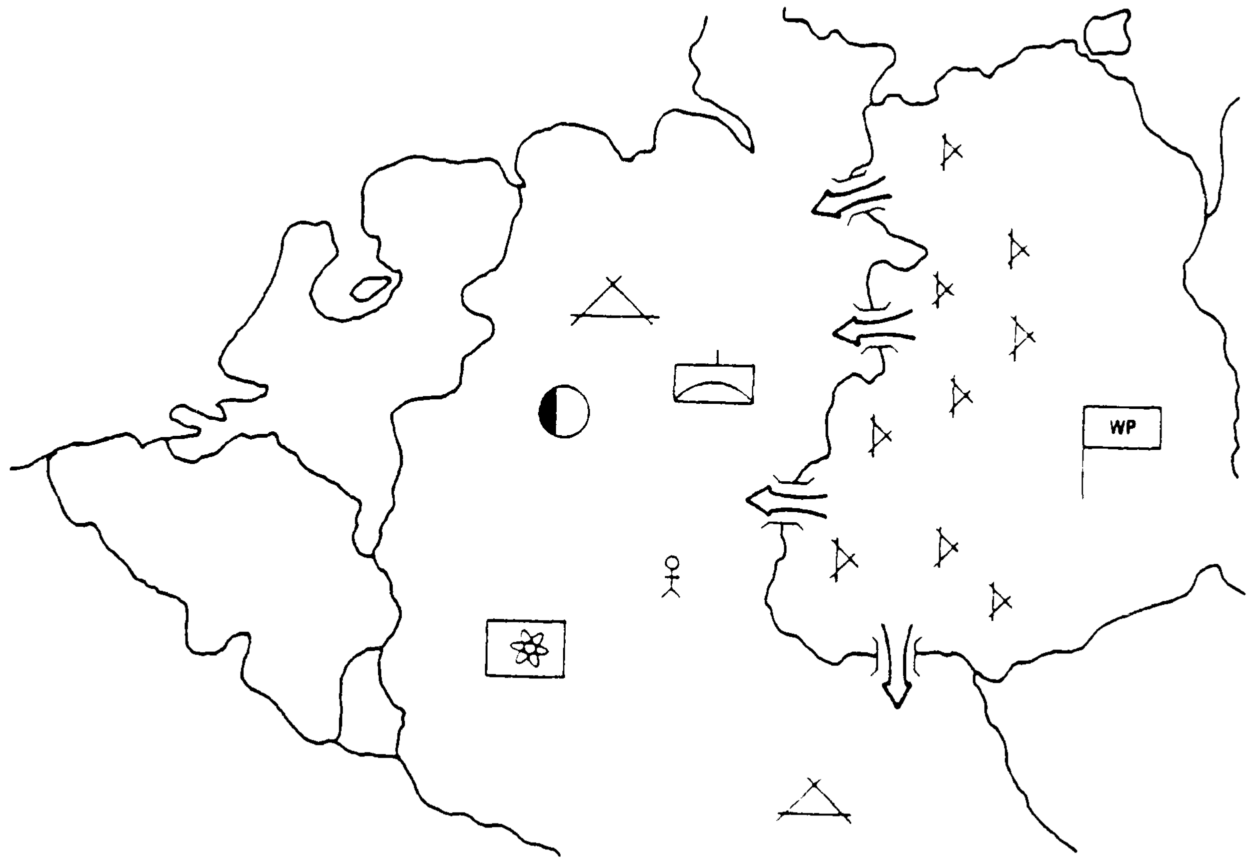

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Figure III-3. MADEM Raid Planning Requirements

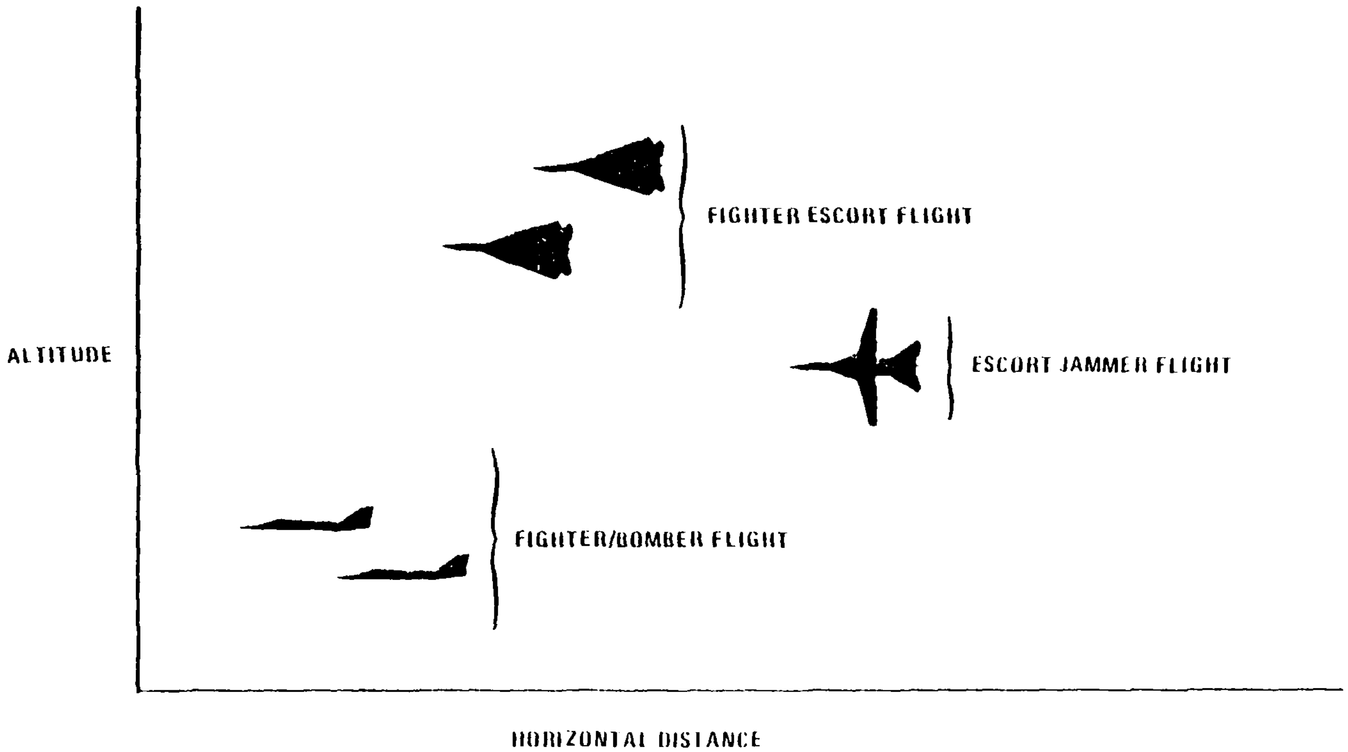

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Figure III-4. Formation Structure

Waves are passed through user selected corridors and attack scheduled targets within bounds prescribed by the user (e.g., maximum and minimum ranges, type targets, corridor "spread angles" and "boundaries"). Flights change course to negotiate passage through corridors and thereafter follow a piecewise linear course to their target and return to home base. Flights change altitude in accordance with user input. If a flight fails to detect its assigned target, there is no opportunity to serach for other targets and the flight returns to home base without inflicting damage. Flights report perceived target damage which is used for subsequent strike scheduling. Figure III-5 illustrates this scenario.

c. Red Threat Planning Data Output

(1) The number and type of flights assigned to attack specific targets from each airbase,

(2) The flight path for each flight, including its formation rendezvous point, passage through the attack corridor, approach to target and return to base,

(3) Target locations and unit numbers.

2. Air-to-Surface Battle

a. Primary Input Data

(1) Ground target types and locations,

(2) Probabilities for locating (detecting) ground targets,

(3) Criteria for neutralizing fire units, and

(4) Fractional damage table for ground targets.

b. Air-to-Surface Capabilities

Each flight is given a probability of detecting its scheduled target based on the nature of the target.

Tactical Air-to-Surface Missiles (TASM) are played but are not released until within the same hexagon as the target. This means that the carrier aircraft may be exposed to attack for an additional one or two minutes prior to the time it might realistically have released its ordnance.

No target in Warsaw Pact territory is attacked. In particular, Warsaw Pact air bases are not damaged and hence aircraft are not attrited because of NATO counterstrikes.

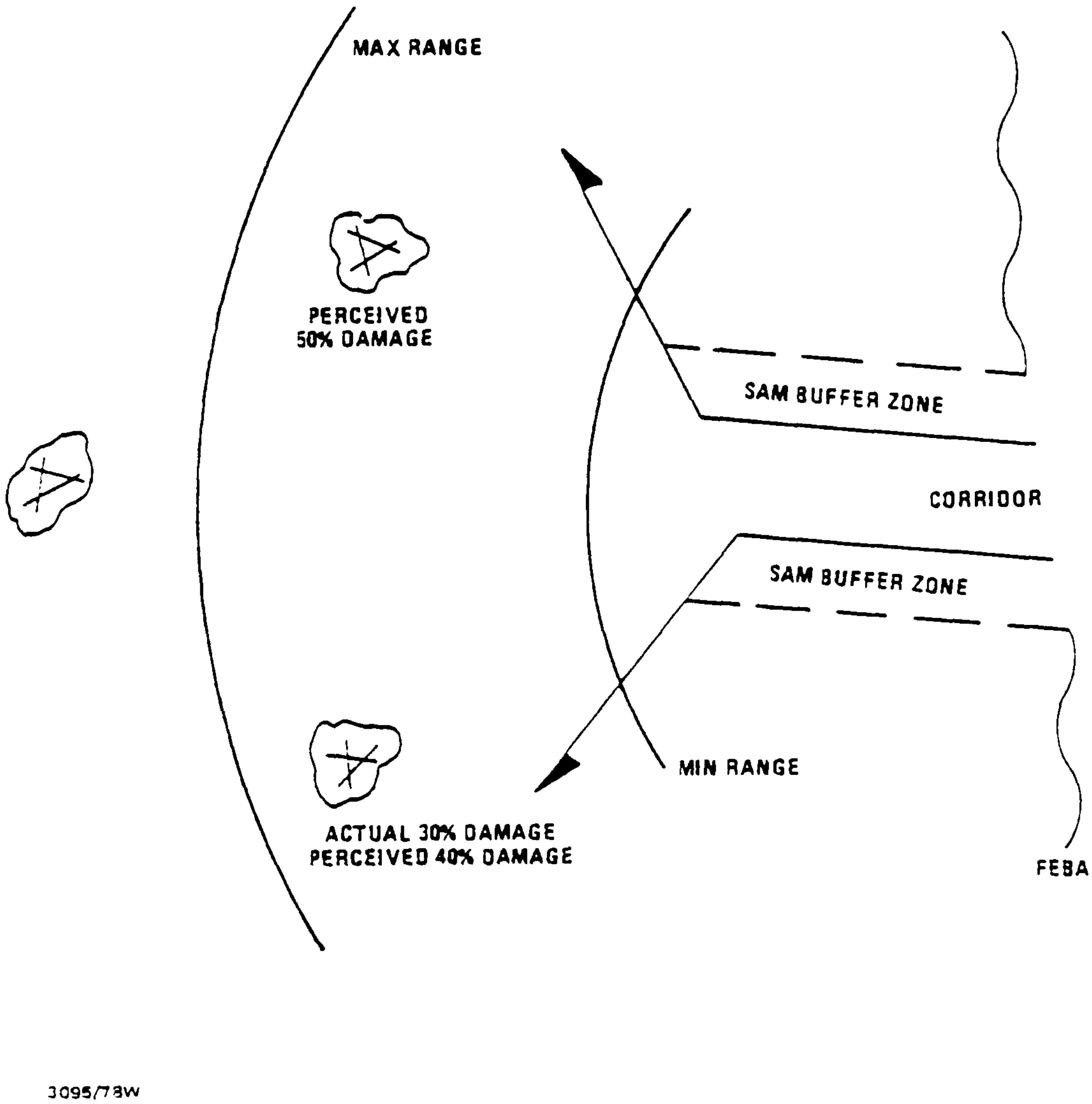

Figure III-5. Scenario Controls

Damage to ground targets is assessed according to the nature of the target. Some targets, such as air defense fire units, are either 100% destroyed or not, dependent upon a Monte Carlo process for the particular ordnance used (assumes the specific targets are the radars). Other targets such as depots, command posts, and nuclear delivery units are damaged in a cumulative manner based on the number and type of ordnance used against the specific target.

c) Air-to-Surface Data Output

(1) The number and types of aircraft reaching their specified targets,

(2) Fractional damage of the given set of targets, and

(3) Air defense fire units neutralized.

3. Air-to-Air Battle

a. Primary Input Data

(1) NATO airbase locations with number and type aircraft,

(2) Aircraft ordnance loading and combat radius,

(3) NATO interceptor flight sizes,

(4) Probabilities of kill for Warsaw Pact and NATO air-to-air ordnance types, and

(5) Operational availability of interceptors is addressed by randomly withholding appropriate numbers and types from the model.

b. Air-to-Air Capabilities

The Control and Reporting Centers (CRC) scramble interceptors upon demands caused by the threat. They are scrambled when hostile flights are detected but are not assigned to specific flights until airborne. Flight sizes are fixed in size based on user input. The flight is vectored to an intercept point by the CRC (or AWACS) until within detection range of the hostile flight. As the threat changes course, the intercept point is relocated accordingly. Visual and/or radar acquisition occurs when the interceptor flight approaches within acquisition range of the hostile flight. Probability of kill is based on type of ordnance loadings for both NATO and Warsaw Pact flights. Targets of opportunity may occur when flights find themselves unexpectedly in close proximity to each other

(e.g., within 20 km). Interceptors return to their departure air base when the hostile flight has been destroyed or when fuel and/or ordnance has been expended. If communications to the CRC have been interrupted the flight will return to its airbase.

Once interceptor flights are landed, a 60 minute (a variable user input) delay time is incorporated in the model to account for rearming, refueling, and minor repair time. Subsequent to this delay, interceptors become available for new assignments. In the current model, NATO airbases are assumed available to service returning interceptor flights regardless of the amount of damage to the air bases, and aircraft on the ground at the time of an attack are not destroyed.

c. Air-to-Air Data Output

(1) Flights acquired and engaged; aircraft destroyed,

(2) NATO interceptors destroyed.

4. Surface-to-Air Battle

a. Primary Input Data

(1) HIMAD and LOMAD Surface-to-Air Missile (SAM) fire unit locations,

(2) Detection/tracking/engagement envelopes for SAM units,

(3) Warsaw Pact aircraft attrition rates due to SHORAD units,

(4) Missile inventories and resupply rates,

(5) Threat assessment criteria (single, few, many hostile aircraft),

(6) Firing doctrine (e.g., shoot-shoot-look),

(7) Crew/system response times,

(8) Probability of detection of air targets,

(9) Probability of kill of air targets by SAM type,

(10) Azimuth limits (patriot) and dead zones, and

(11) Operational availability of SAM units is addressed by randomly withholding, by use of a random number generator, appropriate numbers and types from model input.

b. Surface-to-Air Capabilities

Early warning radars and fire units provide threat data to CRC's. Detection ranges are based on radar line-of-sight with both earth

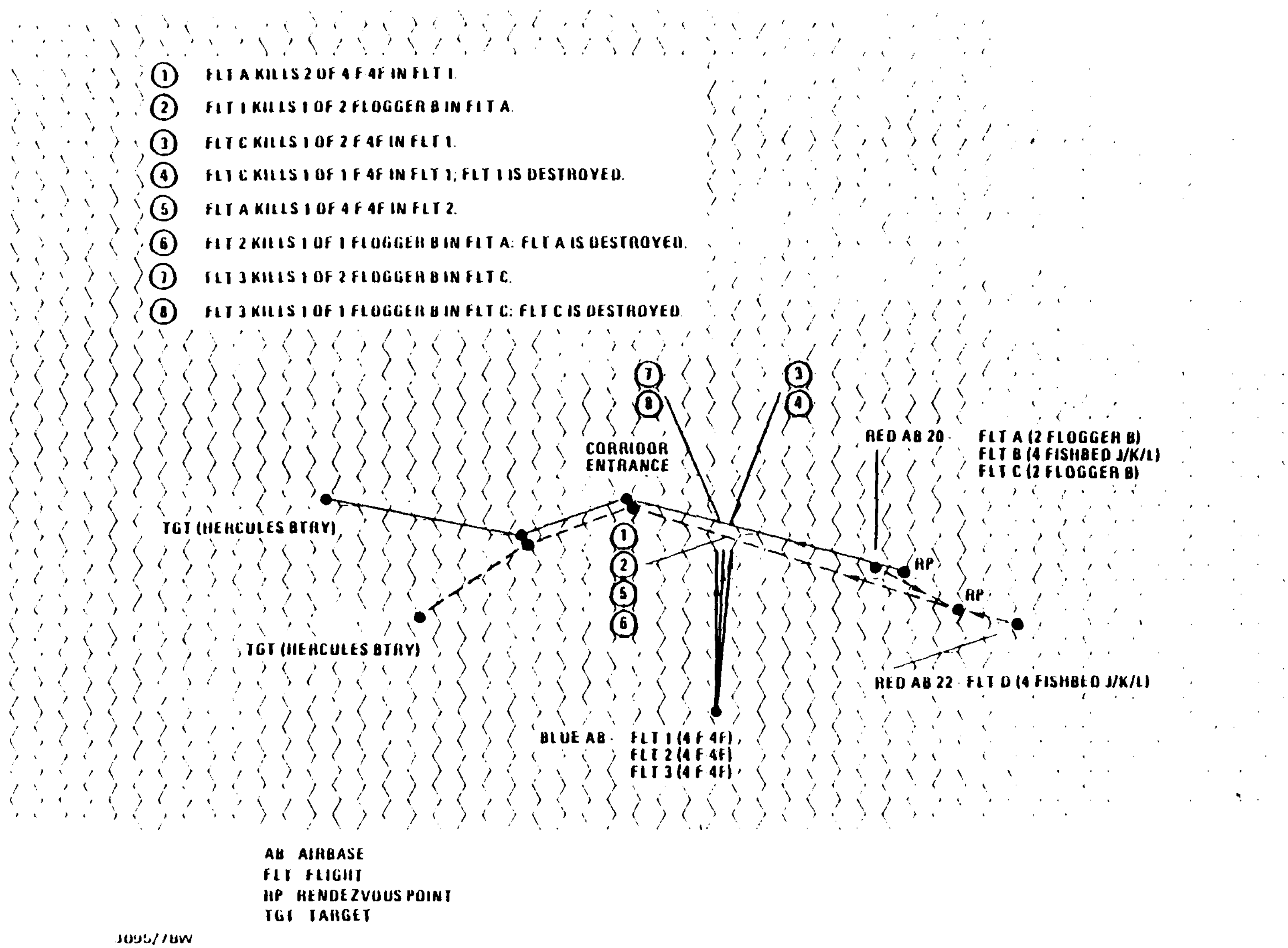

Figure III-6. MADEM Generated Air-to-Air Engagement

curvature and terrain masking considered. A threat can be masked and remasked from a fire unit based on terrain elevations specified for every 25 km hexagonal area. Probability of detection is a function of range.

CRC's assign flight tracks to BOC's. BOC's assign tracks to fire units depending upon the availability of the battery to engage the flight. Fire units have the ability to detect hostile tracks directly if undetected through the CRC. All targets have the same priority for attack (e.g., first seen, first attacked) except that incoming targets are attacked before outgoing targets. Priorities are established when fire units are operating in an autonomous mode.

MADEM determines if the threat flight is within a three dimensional engagement envelope of a fire unit and if the flight has been detected. If both answers are yes, then MADEM schedules a "fire" and an engagement occurs. Launching sequences are based on crew/system reaction times and firing doctrine. Once an engagement has begun, it can not be interrupted (e.g., for masking problems). The firing doctrine for a HAWK fire unit is shoot-shoot-look on the first engagement unless there are less than nine missiles remaining on site. On subsequent engagements of if less than nine missiles remain at the fire unit the doctrine changes to shoot-look-shoot. The Patriot system has the capability of firing multiple simultaneous missions.

SHORAD fire units are implicitly modeled; they cause attrition of hostile flights uniformly over all NATO territory.

Nike Hercules, HAWK, and Patriot units are resupplied with missiles in accordance with prescribed resupply rates.

Figure III-7 illustrates two MADEM generated formations with HAWK engagements.

c. Surface-to-Air Data Output

(1) Number of aircraft detected and acquired,

(2) Number of missiles fired,

(3) Number of aircraft destroyed.

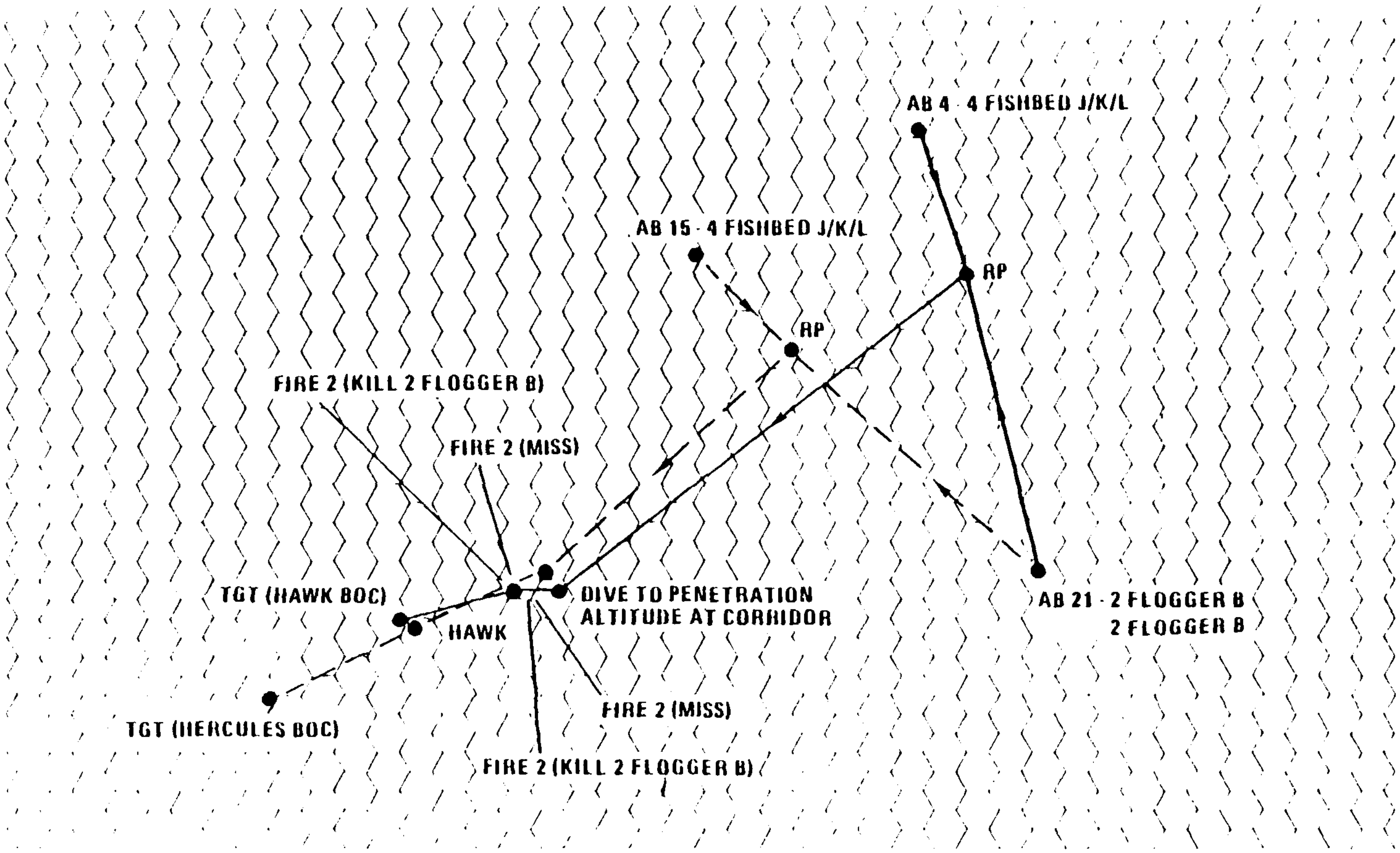

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Figure III-7. MADEM Generated Ground-to-Air Engagement

5. <u>Command, Control and Communications (C^3)</u>

a. <u>Primary Input Data</u>

(1) C^3 relationships and location of nodes,

(2) Primary Target Lines (PTL) for SAM units, and

(3) Probability of misidentifying a flight of aircraft

b. <u>C^3 Capabilities</u>

For the base case, the highest state of air defense alert is assumed. That is, air defense elements are in Emergency Defense Positions (EDP) and the appropriate degree of readiness of each available system has been achieved.

The base case plays a CRC mode of control. This means the CRC receives threat data from early warning radars and fire units and assigns targets to air bases and interceptors or to SAM BOC's and fire units. Fire units may be at battery level in the case of Nike Hercules, or at platoon level in the case of HAWK and Patriot. In this mode of control the CRC does not coordinate with other CRC's and hence it is possible that two or more CRC's may assign different air defense elements the mission of attacking the same target at the same time. If a fire unit can not engage an assigned flight, a message is sent to the BOC and hence to the CRC so stating. The target is then reassigned by the CRC. No alternate communication routings are possible. Message traffic is delayed four (4) seconds for each transmission. Reference Figure III-8.

The present state of MADEM does not permit explicit modeling of various Weapons Engagement Zones (WEZ) because of the complex geometry involved. A modified WEZ is played, however, by prohibiting HIMAD units from firing at targets below a specified altitude where probability of kill is less and by prohibiting LOMAD units from firing at targets above a specified altitude regardless of geographical locations of fire units. Interceptors operate anywhere as directed by the CRC.

Minimum burst altitudes are prescribed for various yield nuclear SAM warheads.

Imperfect identification is played. Once a hostile target is misidentified it can be correctly identified at a later time by interceptors at time of engagement. Subsequently, the CRC may correct its

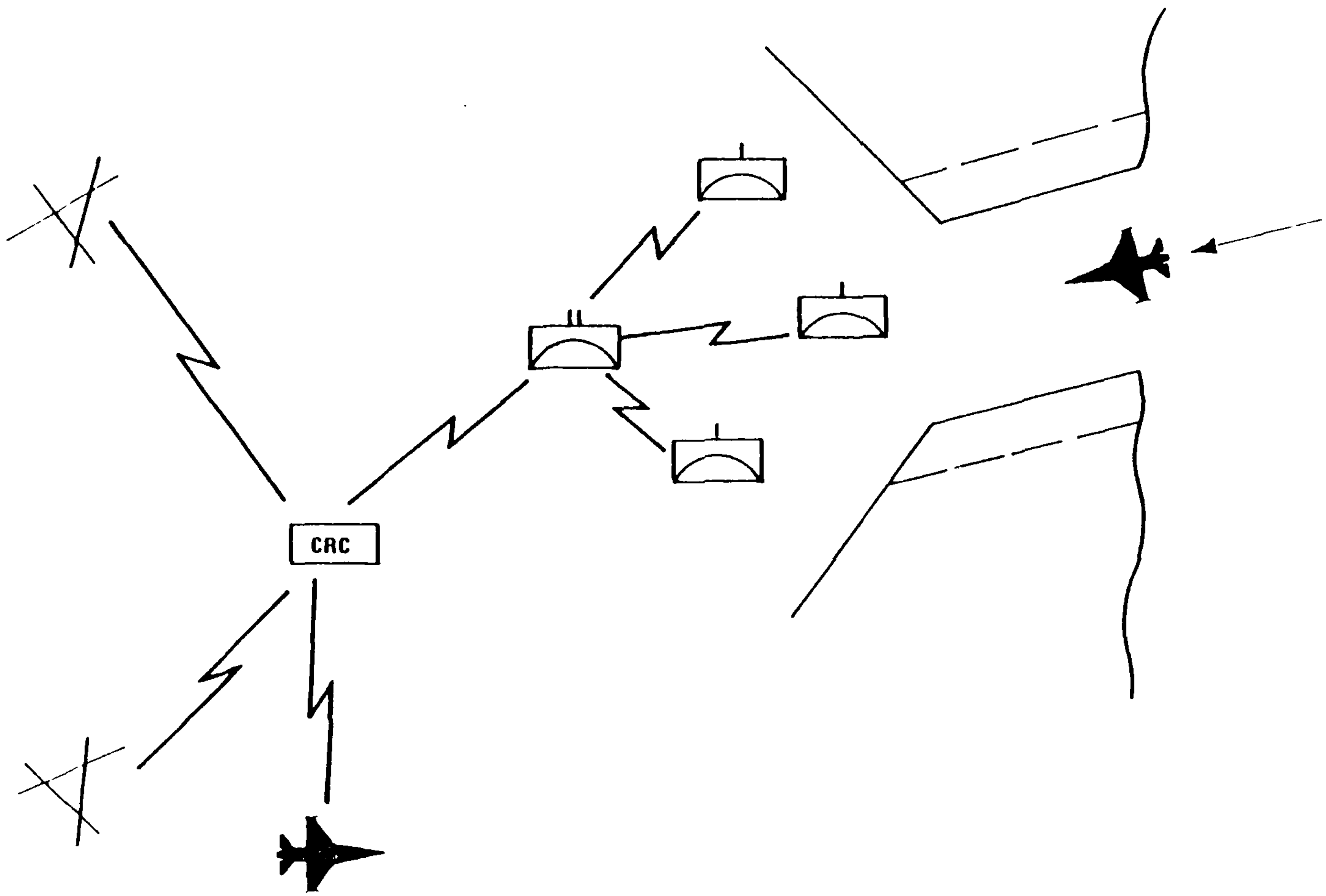

Figure III-8. CRC Mode Of Control

misperception. Misidentification of friendly aircraft may be corrected only if the aircraft has not been assigned to a SAM unit.

AWACS can detect hostile flights and vector fighter interceptors but is not attacked by hostile flights. No NATO aircraft are dedicated to AWACS defense.

Air defense units assume the highest state of alert and revert to autonomous operations when communications to higher organizations are lost. This can occur when a CRC or BOC has been neutralized by hostile flights or when the effects of Electromagnetic Pulse (EMP) destroys communications equipment. For SAM fire units, priorities for engagement are to flights approaching along the unit's primary target line, to all other incoming flights, and finally to outgoing flights. For air base defense, a flight of interceptors is scrambled to one of seven (randomly selected) hexagons adjacent to the airbase by a "dummy CRC". When a hostile flight is detected by the airborne flight, the "dummy" CRC scrambles all available flights to adjacent hexagons where air-to-air battle ensues in accordance with target of opportunity rules of engagement. The dummy CRC lands the interceptors when the threat has passed.

6. <u>Electronic Warfare (EW)</u>

a. <u>Primary Input Data</u>

Degraded detection and engagement ranges.

b. <u>EW Capabilities</u>

In an EW environment, MADEM degrades the operational characteristics of all NATO air defense units uniformly across the defended area by type system. The worst electronic countermeasure threat for each type system is used to degrade the performance of the system. Frequency and power characteristics of jammers are considered in arriving at the degraded performance characteristics of NATO air defense units.

7. <u>Nuclear Environment</u>

a. <u>Primary Input Data</u>

(1) Criteria (size/altitude of threat flights and minimum normal burst altitude) for the CRC to make assignments of nuclear weapons by type warhead, and

(2) Probability of kill of nuclear air defense weapons.

b. Nuclear Capabilities

Nuclear air defnese missiles are employed based on a logic criteria that considers threat size, altitude, and Minimum Normal Burst Altitude (MNBA). It is assumed that separation distances between aircraft flying above MNBA are such that a nuclear burst will destroy at most a single plane.

When a nuclear burst occurs, all communications within the same hexagon as the burst are disabled for the duration of the raid(s). If communictions are lost in this manner, subordinate units operate in an autonomous mode.

SECTION IV
MODEL SPECIFICATIONS

A. INTRODUCTION

This chapter documents the basic specifications of the MADEM simulation. Its purpose is to explain the structure and assumptions which underly the processes modeled in MADEM. While this chapter deals with the processes modeled in some detail, it does not attampt to cover the actual implementation of the model in the FORTRAN code. Users who require more detailed information on model implementation are referred to the MADEM Programmer Manual and Source Listings.

B. SIMULATION ARCHITECTURE

1. Modularity

The model was developed along functional lines so that each major function exists as a semi-independent section of the model. Each major function is referred to as a module. The modules are further divided into smaller segments each of which contains the logic for a single decision or physical operation.

Each function represents some specific air activity or event. For example, the perceptions of enemy aircraft are handled in a module separate from the module that makes decisions to fire on those aircraft. Within the perception module are the various segments such as the one that determines line of sight intervisibility between a battery radar and a flight of aircraft.

The various segments and modules of the model are tied together through a centralized software control system that manages the overall functioning of the model. This centralized software control system, in addition to providing basic data processing functions such as input and output control, provides the sophisticated list processing technique which is the basis for much of the power of the MADEM architecture. Module functions are summarized in Table IV-1.

TABLE IV-1. MADEM MODULE SUMMARY

MODULE/CONTROL ROUTINE		FUNCTION
ASSIGN	-	Combat reporting center makes assignments of interceptors to Red flights.
ATTACK	-	Carry out ground attack by Red flights.
COMMO	-	Communications transmission
DOGFITE	-	Surface-to-air missile engagement decisions
FLY	-	Aircraft movement
NAYBOR	-	Determine nearby units & schedule all units for a chance to "see" an action.
PERCEPT	-	Controls perception of other units.
PLAN	-	Red threat planning
PONDER	-	Unit information processing.
TOWER	-	Air base operations
UMPIRE	-	Determines outcome of missile launches.

2. Discrete Events

MADEM is a player centered, discrete event simulation. The simulation is made up of three fundamental components - entities, actions and processes. Entities are the units which actually participate in battle as active players. These player units may take actions which affect their environment including other units. The processes simulated in MADEM are, in fact, composed of many discrete actions taken by entities interacting with each other in the battle area over time. Units take actions in response to their perception of the environment. When an action is taken the unit schedules an event or series of events which corresponds to the action to occur some time in the future of the battle. The time between the decision to take an action and the scheduled time of the event reflects the time lag inherent in the action being taken.

Each player must schedule many events in the course of the simulation. As a result, the number of events that must be managed by the simulation in a typical scenario is quite large. For example, an average MADEM historical tale contains over 240 events for each second of battle. The interaction for these events is controlled by the Simulation Control Software (SCS). The SCS sorts all scheduled events to insure a logical progression of events. It also interprets the events as they occur in the sequence of battle and activates the appropriate software module to simulate the desired processes. When a player unit is destroyed or incapacitated to the point where its future events cannot be expected to occur, the SCS withdraws the unit's future events from the schedule.

3. Action Cycle

Model processes, as represented by the software modules listed in section II-B-1, are driven by a three phase, player centered, action cycle. Figure IV-1 illustrates this cycle. The cycle is initiated by an action taken by a player unit. The initiating action is usually a movement. However, other actions including attacks, deaths and messages may also initiate the cycle. These initiation actions are then perceived by player units through their respective acquisition and communications devices. The nature and status of the units acquisition and communications devices will

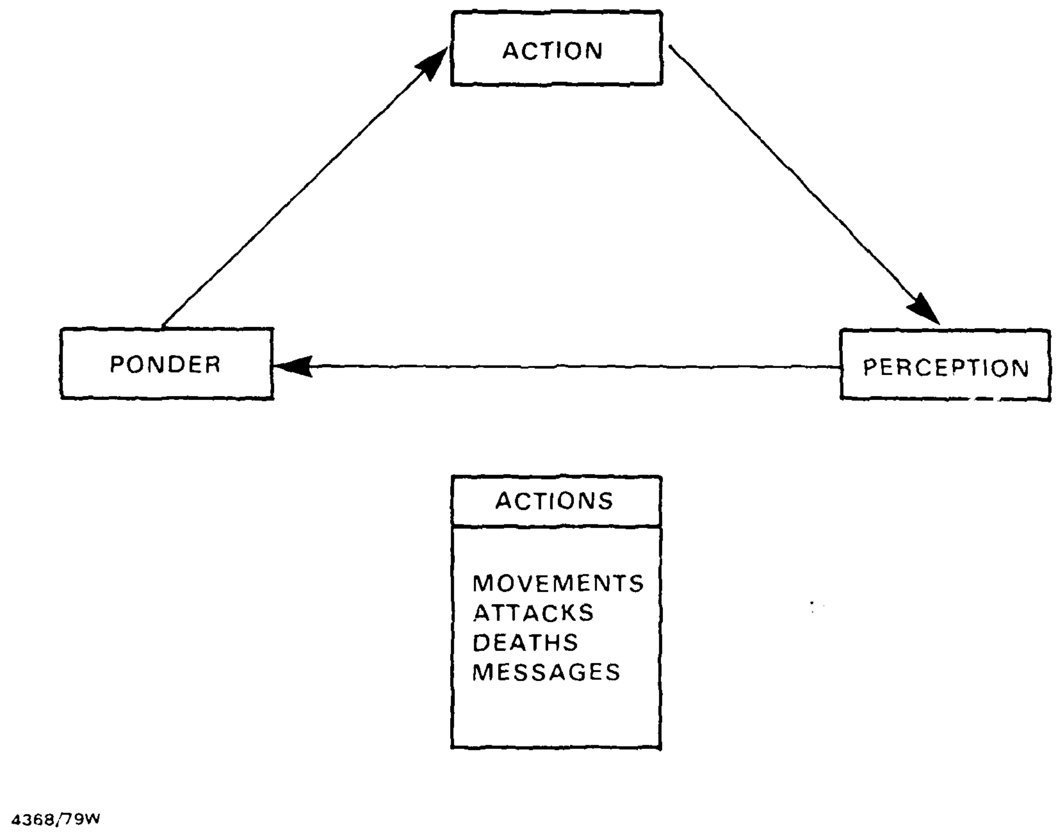

Figure IV-1. MADEM Action Cycle

determine the extent to which perceptual data is distorted. For example, it is possible for interceptors to incorrectly identify a Blue flight as a Red flight.

Perceptual data is then pondered to determine the appropriate action for the perceiving unit to take. The ponder phase of the cycle is analogous to a units consideration of actions to be taken in response to external events. The time a unit requires to ponder and react to perceptions varies with the unit type and the complexity of the action perceived. Actions resulting from the ponder phase reinitiate a new cycle.

4. Units Represented

Two types of units are explicitly represented in MADEM player units and non-player units. Player units actively participate in the battle while non-player units act as passive targets for Red attacks. All units may be targeted. However, only active players may initiate or respond to attacks. Figures IV-2 and IV-3. illustrate the Blue and Red command structures modeled in MADEM. Valid player and target types are listed in Appendix E.

Combat Reporting Centers (CRC) are the highest ranking active player on the Blue side. Although the Allied Tactical Airforce (ATAF) and Sector Operations Center (SOC) command levels are represented, their functions in the current version of the model are implicit. They act only as conducts for communication between combat reporting centers (CRC) within the model software. Enhancements currently under development would result in the ATAF and SOC's becomming active participants in the allocation of Blue air defenses.

The Red Theater Commander (RTC) is the highest ranking active player on the Red side. It is responsible for allocation of Red penetrator flights to appropriate targets. Since the Red side is never attacked by Blue, the Red command structure does not include defensive units such as battalion operations centers (BOC) and surface-to-air missile batteries (BTRY).

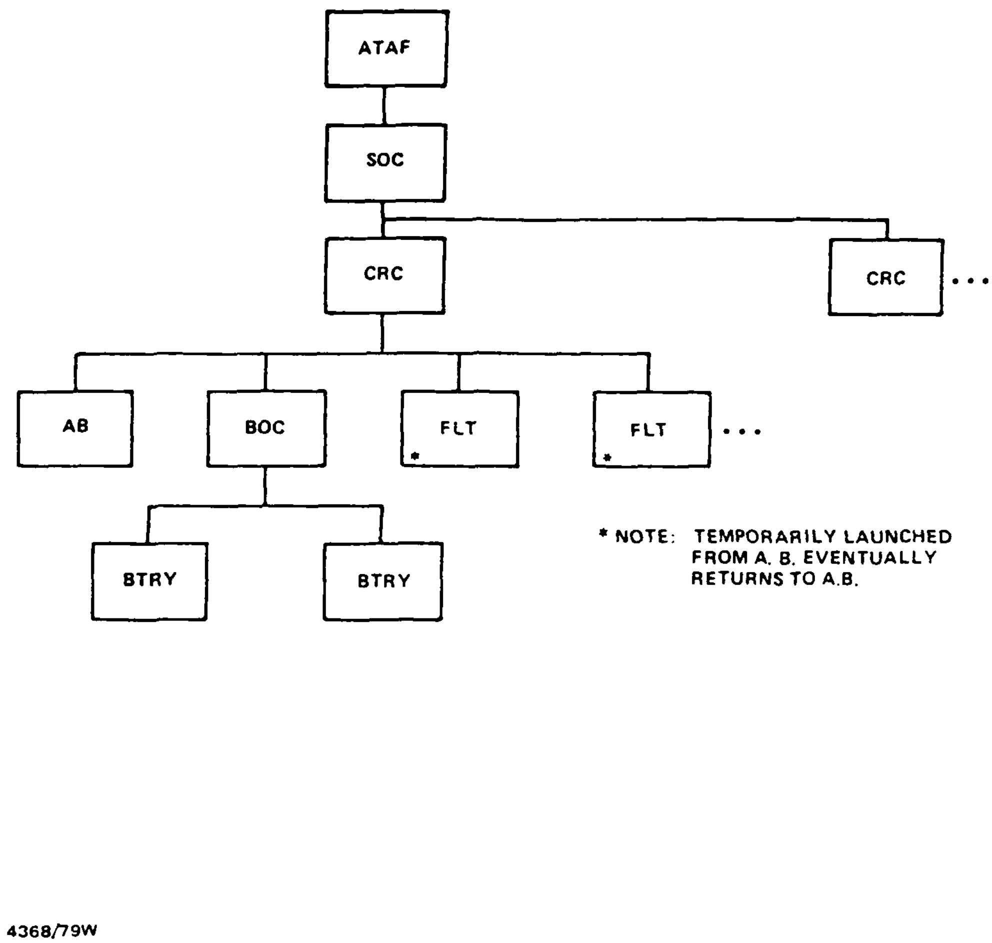

Figure IV-2. Blue Command/Control Structure

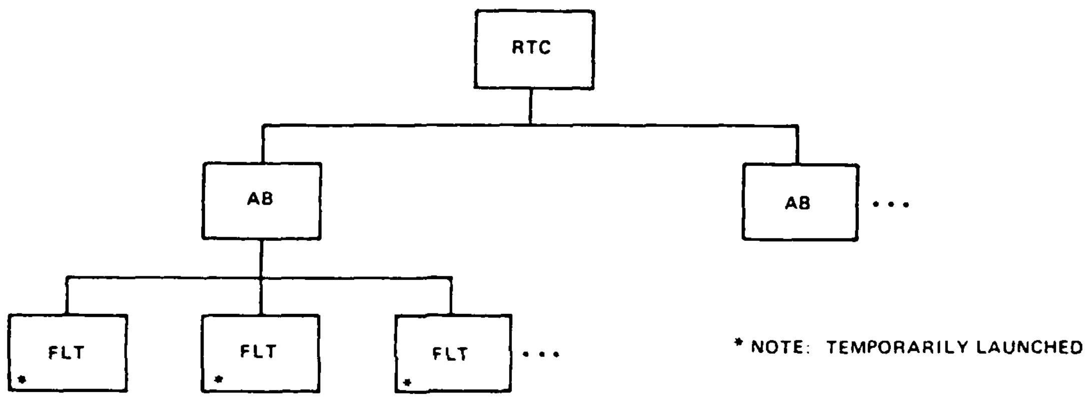

Figure IV-3. Red Command/Control Structure

C. DEFINITIONS OF PLAYERS

1. Combat Reporting Centers (CRC)

The combat reporting centers are the highest ranking active player on the Blue side. CRC's control the actions of all subordinates which are capable of communication with the CRC. The CRC's are responsible for acquisition and identification of threat aircraft within their zones of control. They are also responsible for allocation of defense units to incoming Red penetrators.

In the course of fulfilling these responsibilities the CRC units perform the following functions:

(1) Acceptance of early warning information

(2) Determination of type of subordinate to engage threats

(3) Request of interceptor launch by air bases

(4) Assignment of threats to specific subordinates

(5) Receipt and processing of engagement status information from subordinates

(6) Vectoring of interceptors to assigned threats

2. Red Theater Commander (RTC)

The Red theater commander (RTC) is the highest ranking active player on the Red side. The RTC is the core of the Red Threat planning process. It interprets general attack specifications input by the user and converts them to a set of specific flight plans which are used to carry out the attacks. The RTC controls execution of waves and raids as well as the channeling of penetrator flights through appropriate corridors. In addition, the RTC chooses specific targets to be attacked based on target location, damage level and available aircraft types.

In the course of fulfilling these responsibilities the RTC performs the following functions:

(1) Interprets user input attack specifications

(2) Perceives location and damage level of potential targets. (Red perceptions may differ from reality)

(3) Constructs general resource limits for each wave and raid.

(4) Defines specific formation components

(5) Determines takeoff times for flights which make up the formations

(6) Sets flight plans (including rendezvous points) for each flight.

(7) Allocates flights to specific targets

3. <u>Air Bases (AB)</u>

Air bases are the only player unit type used by both the Red and Blue sides. Both Blue and Red air bases are capable of keeping track of the number and type of aircraft on the air base as well as the status of each aircraft type in terms of launch capability.

Air bases perform the following functions:

(1) Accept launch requests from CRC or RTC.

(2) Launch available aircraft on request

(3) Hold returning aircraft for refueling, rearming, etc.

(4) Antonomous launching of aircraft to CAP orbit when not under control of a CRC. (Blue only)

4. <u>Battalion Operations Centers (BOC)</u>

Battalion operations centers (BOC) exist only on the Blue side. BOC's report to CRC's and command surface-to-air batteries. BOC's are responsible for coordinating assignment of incoming Red targets to SAM batteries under their command. They are also responsible for monitoring engagements and reporting results to the CRC. Three types of BOC are currently simulated: HAWK, NIKE-HERCULES and PATRIOT.

In the course of fulfilling these responsibilities the BOC's perform the following functions:

(1) Acquisition/IFF of threat aircraft

(2) Acceptance and passage of early warning information to the CRC.

(3) Providing engagement status reports to the CRC.

(4) Acceptance of penetrator assignments from the CRC

(5) Digestion of information on assigned threats and scheduling of subordinates' engagements.

(6) Prioritization of threats

(7) Assignment of threats to particular batteries

(8) Receipt and processing of engagement and battery status reports from subordinates

(9) Antonomous selection of threats for engagement, when not under control of CRC

5. Batteries (BTRY)

Surface-to-Air batteries (BTRY) exist only on the Blue side. BTRY's report to BOC's and are composed of multiple time units. BTRY's are the lowest ranking active player on the Blue side. BRTY's perform the following functions:

(1) Acquisition/IFF of threat aircraft

(2) Passage of early warning information to BOC

(3) Acceptance of assignments from BOC

(4) Providing engagement and battery status reports to BOC

(5) Digestion of information on assigned threats

(6) Allocation of fire units to engage threats

(7) Reloading and request for resupply

(8) Autonomous operation when not under control of BOC.

6. Aircraft Flights (FLT)

Flights (FLT) are the basic maneuver unit in MADEM. They exist on both the Blue and Red sides. Flights consist of one or more aircraft of the same type launched from the same air base. ghts are unique in that they are temporary entities. In response to an order from a CRC or RTC an air base constructs a flight of the requested type from the available aircraft on base. Upon launch a new flight entity is created. This entity acts as a player unit in the battle until it is either destroyed or returns to base. While the flight is airborne it reports directly to the CRC that commands its originating air base. When the flight returns to base it ceases to exist as a separate player entity and its component aircraft are returned to the air base's pool. While airborne, flights perform the following functions:

(1) Move on a 9.45 km hexagonal coordinate system.

(2) Fly a sequence of straight-line segments

(3) Rendezvous with other flights to form formations which proceed against assigned targets

(4) Perform maneuvers at checkpoints between flight-path segments, possible maneuvers include:

- change direction
- change velocity
- initiate altitude change

(5) Check fuel on each move and head home when supply is low.

(6) Each movement of a flight results in a new opportunity for other players to acquire and identify it.

D. NON-PLAYERS

In addition to the player units described in the previous section, MADEM also contains a variety of non-player units. These Blue units are non-players in the sense that they act only as targets for Red attacks. These passive target units may be used to represent a wide variety of significant penetrator targets which have no active air defense capability. A complete listing of non-player unit types is contained in Appendix E.

E. DETAILED PROCESSES

1. Red Threat Planning

a. Planning Process Overview

1) Red Attack Structure

The Red Attack is carried out in a series of raids each of which is made up of a number of waves. Raid and wave start times are generally sequential and result in an attack structure similar to Figure IV-4. Each raid and its component waves are planned by matching formation and targeting requirements with air base and corridor locations. Subsequent raids are based upon Red aircraft attrition, new targeting requirements, and perceptions of damage caused by previous raids. Figure IV-5 illustrates a simple MADEM scenario.

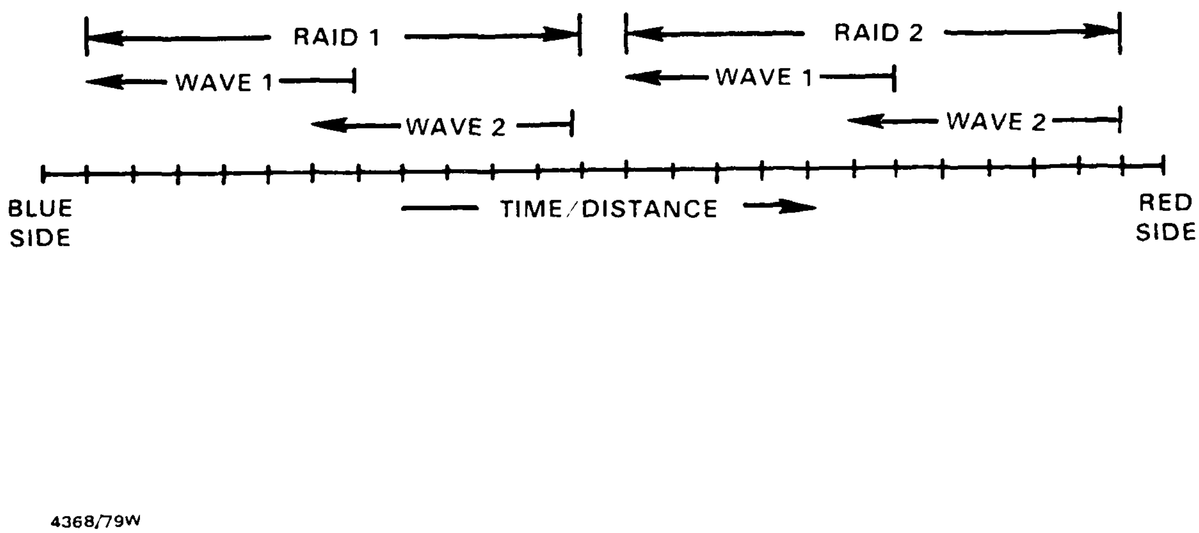

Figure IV-4. Red Attack Structure

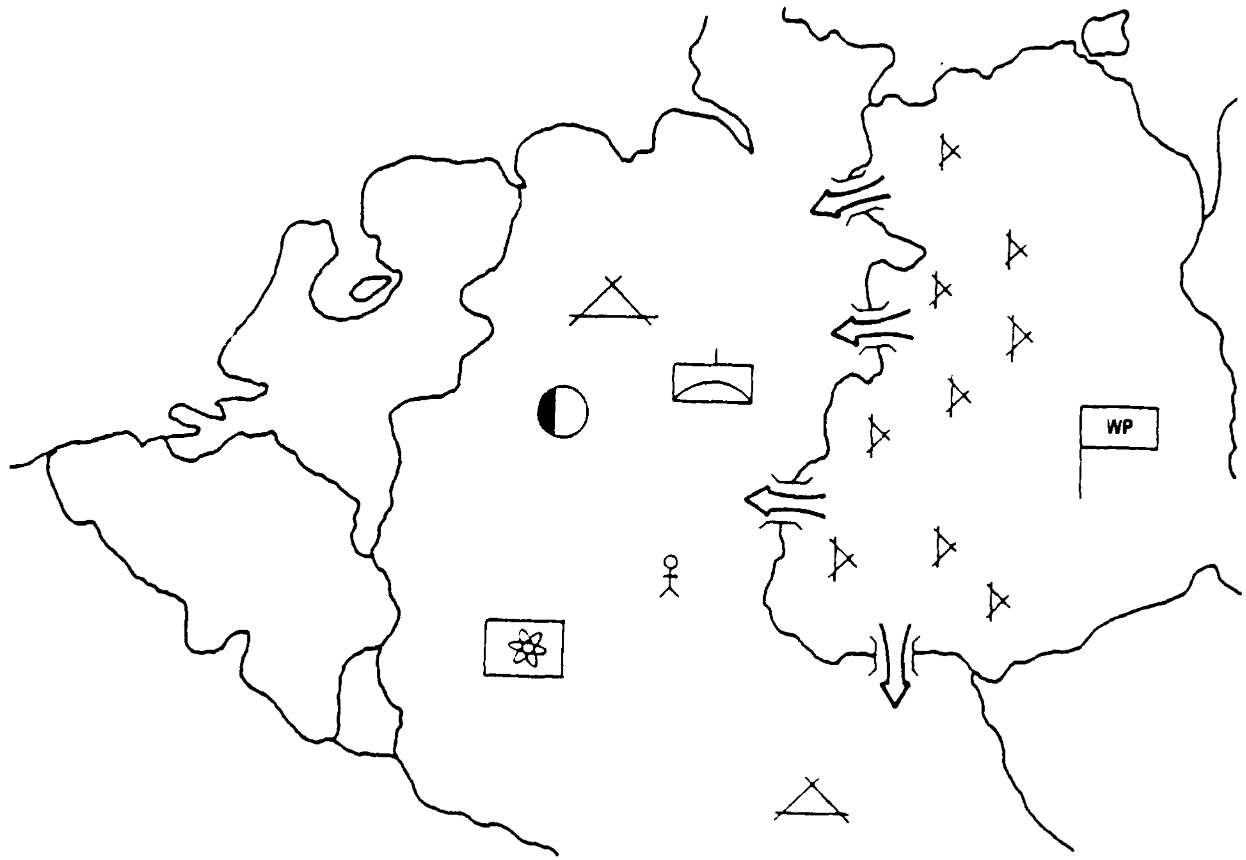

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Figure IV-5. A Simple MADEM Scenario

The basic maneuver unit in MADEM is the "Flight". Each flight consists of aircraft of the same type scheduled against a specific target. Flight types consisting of specified numbers of aircraft are assigned to formation types by the user. (Figure IV-6). Individual aircraft are not tracked. However, they are accounted for when the flight is attacked and aircraft kills result.

Flights are assembled from aircraft located on the air bases. Each air base keeps track of the number and type of aircraft on the base. All bases have user specified recovery to launch delay times associated with aircraft types which determine the rate at which flights can be launched. Only complete flights may be launched. If there are insufficient aircraft on the base to assemble a desired flight type, the flight is not launched and the aircraft remain on the base as surplus for the next raid.

Flights launched from the air bases rendezvous to form formations. Formation types are assigned to attack various target types by the user. Individual formations are assigned to attack individual targets by the PLAN module. Formations launched during the same specified time period constitute a wave.

Waves pass through user specified attack corridors and attack scheduled targets within bounds prescribed by the user (e.g., maximum and minimum ranges, type targets, corridor "spread angles" and "boundaries"). Figure IV-7 illustrates a typical corridor. Normally these corridors will be cleared of Blue SAM batteries by the first Red flights entering the corridor. Flights change course to negotiate passage through corridors and thereafter follow a piecewise linear course to their target and return to home base. Flights also change altitude during their missions in accordance with user input mission profiles. If a flight fails to detect its assigned target, there is no opportunity to search for other targets and the flight returns to home base without inflicting damage. Flights report percieved target damage which is used for subsequent strike scheduling. Figure IV-8 illustrates a typical mission profile.

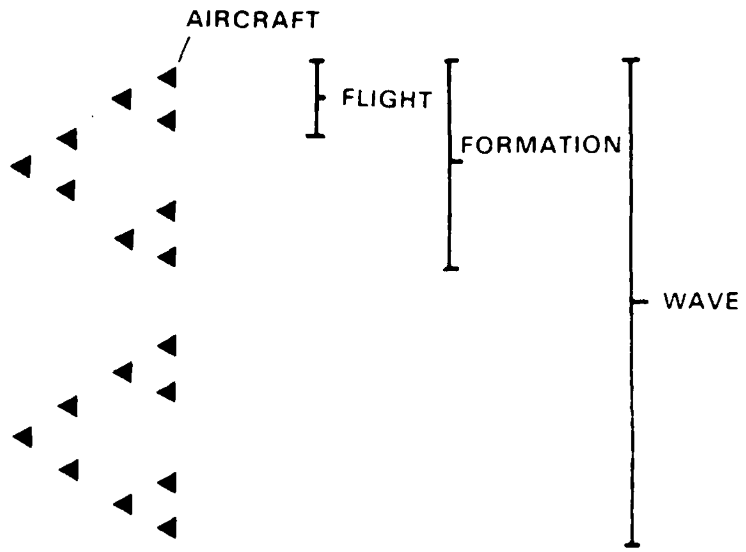

Figure IV-6. Red Wave Components

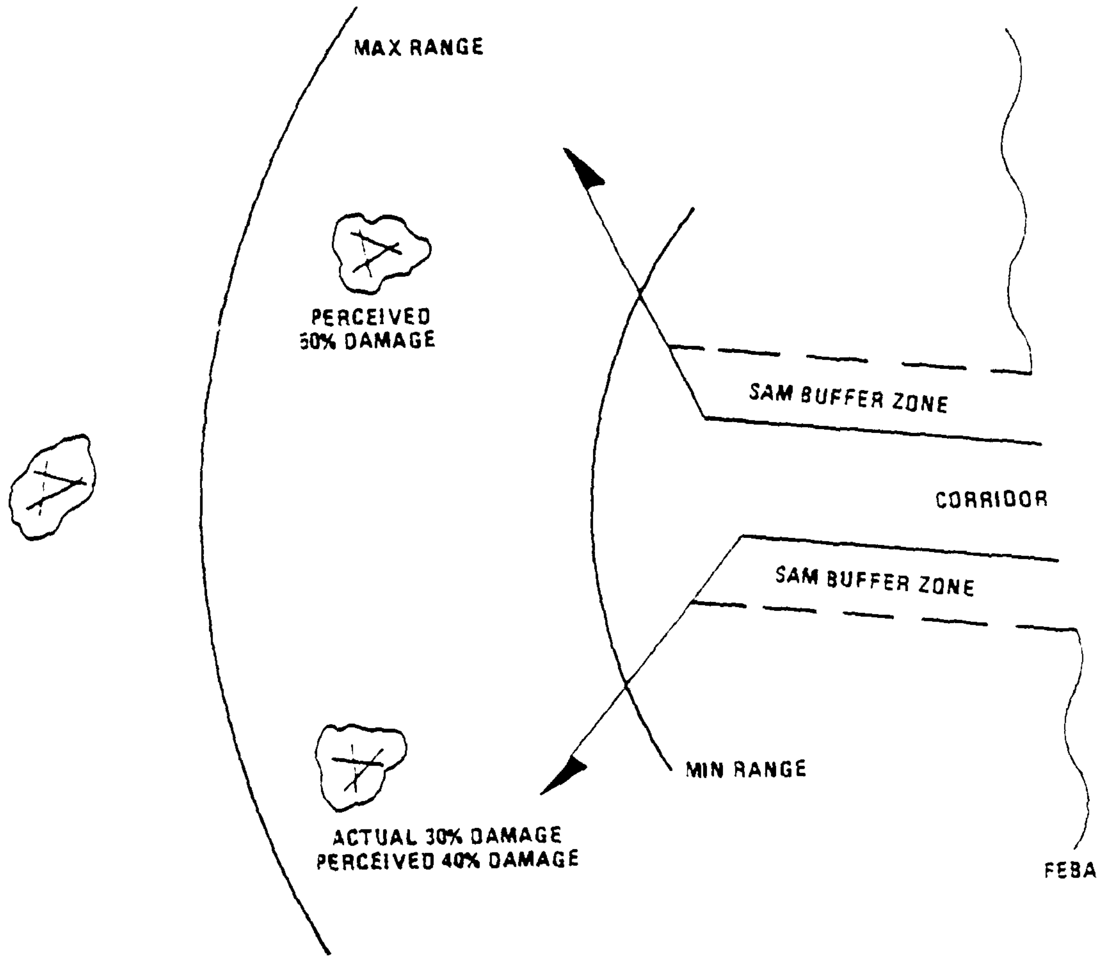

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Figure IV-7. Corridor Configuration

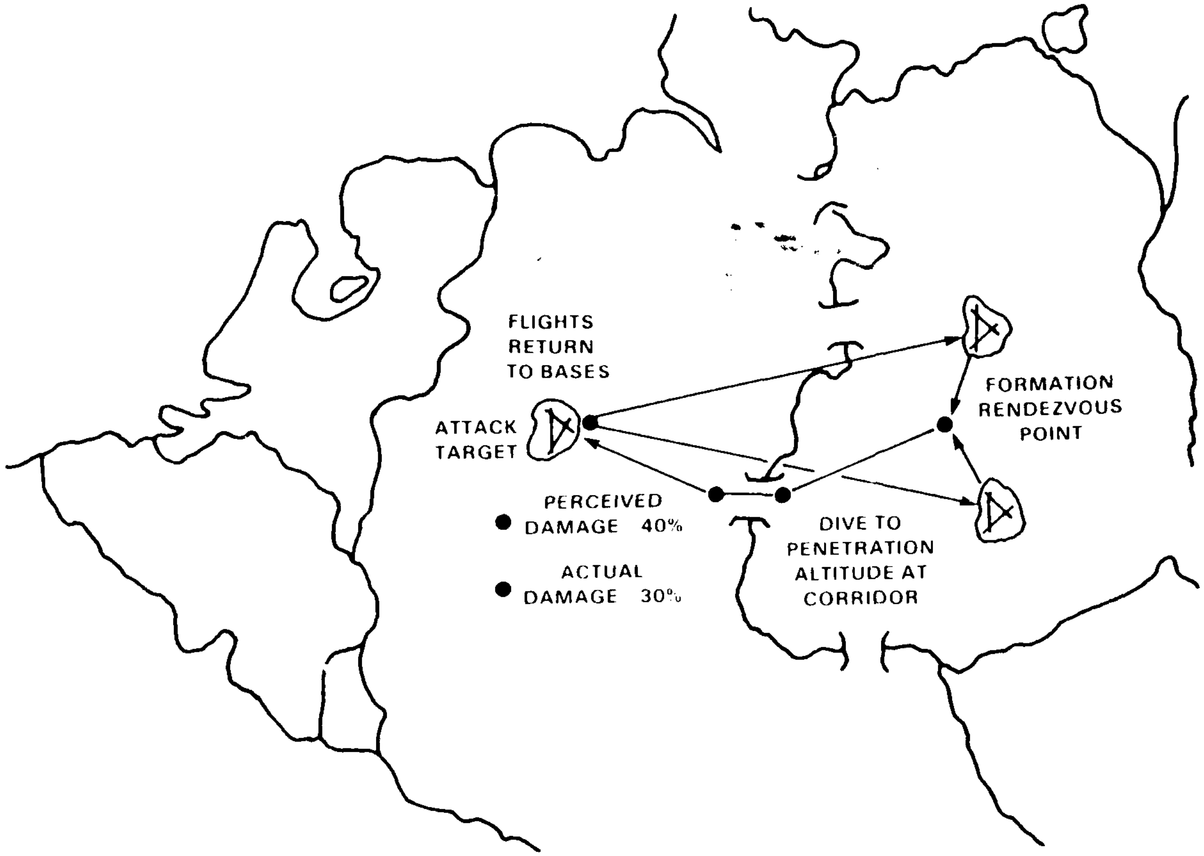

Figure IV-8. A Typical Mission Profile

2) The Planning Cycle

The cyclical threat planning process used by MADEM is illustrated in Figure IV-9. At the beginning of a run the user inputs the specifications for each raid (listed in section C.1.b). Target assignments and corresponding flight orders are then generated by the PLAN module subject to aircraft resource constraints. After the initial raid has been carried out, the surviving Red aircraft return to their bases and report percieved target damage levels to the PLAN module. If subsequent raids have been specified by the user, the PLAN module adjusts target priorities based on its remaining aircraft resources and generates new target assignments and flight orders for the next raid. Once the process has been initiated by user inputs the planning and attack process is self contained. All subsequent raids will be carried out without user intervention.

3) Planning Stages

Red threat planning is carried out in four major stages which may be summarized as follows:

(1) Corridor Boundary Specification - Attack corridors must be. respecified for each raid.

(2) Overall Resource Allocation - User specified formation to target type assignments are compared to available formations by type. Assignments are proportionally adjusted to account for descrepancies between user specified requirements and available resources for each raid.

(3) Target Assignment - Individual formations are assigned to specific targets based on formation, availability and specific target selection criteria for each wave.

(4) Flight Scheduling - Orders for specific flights to join formations and attack specific targets are generated for each wave. These orders include launch times and mission profiles.

Each of these stages is composed of a number of steps. The detailed operation of each stage is discussed in the following sections - C.1.d, C.1.e, C.1.f, and C.1.g.

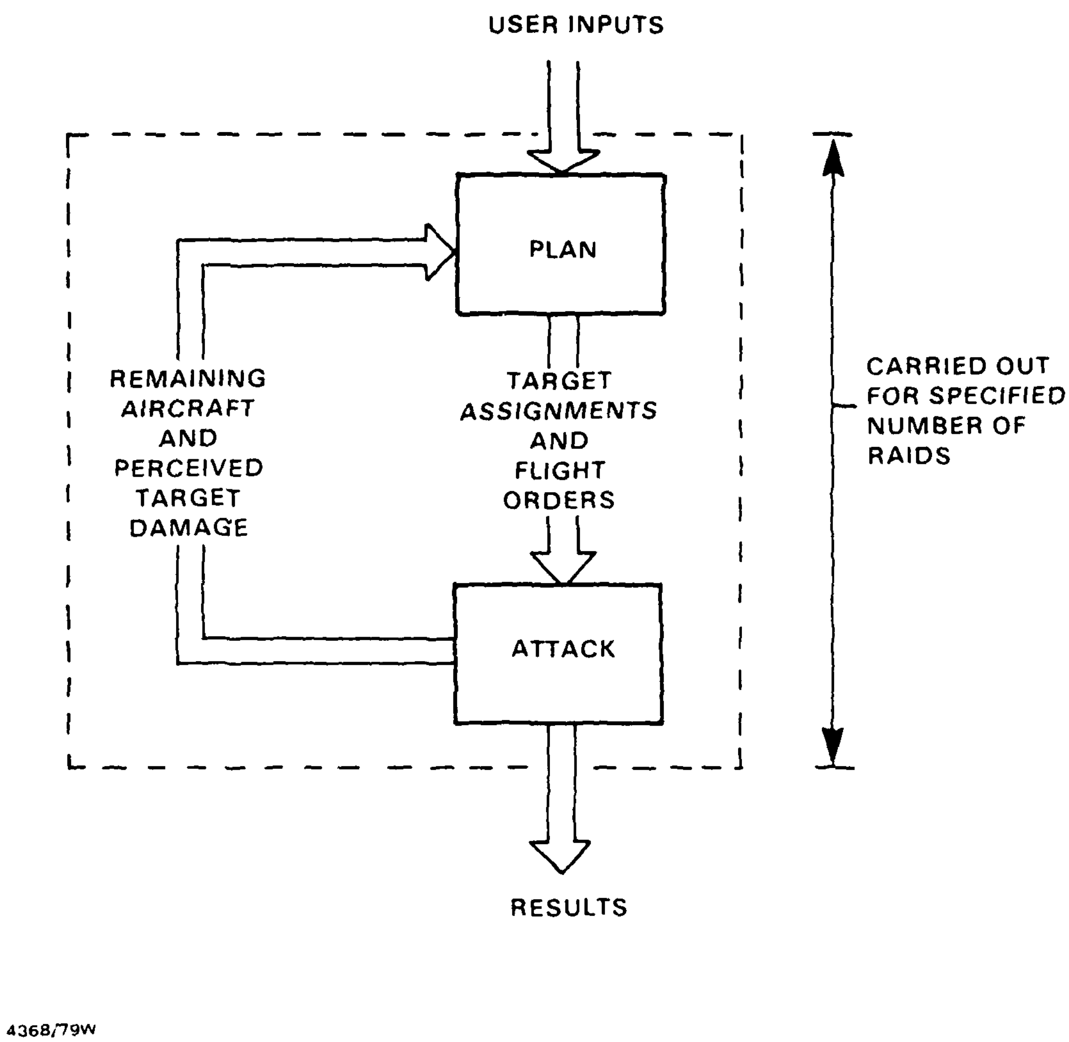

Figure IV-9. The Red Threat Planning Cycle

b. Corridor Boundary Specifications

Attack corridors must be specified by the user for each raid. Required inputs for each corridor include the corridor limit locations, corridor heading, spread angle, and buffer zone width. The relationship of these inputs to a hypothetical attack corridor is illustrated in Figure IV-10.

Processing of these corridor specifications by the plan module results in creation of a set of geographic zones for each corridor. These zones, which are illustrated in Figure IV-11, are used in the target assignment stage of planning to determine the geographic suitability of specific targets. All targets in zones 1 and 4 are acceptable, while targets in zone 0 are unacceptable. HAWK batteries located in zones 2 and 3 are acceptable. However, all other targets in zones 2 and 3 are unacceptable. The purpose of this target classification scheme is to insure that the corridor and its buffer zones are cleared of Blue units which can shoot into the corridor center.

c. Overall Resource Allocation

The total available aircraft resources are allocated to user specified target types for each raid. This process attempts to reconcile any descrepancies between the attack resource assignments for each target type input by the user with actual resources available. This stage of the planning process is carried out in the following three steps:

(1) Determine for each wave the number of aircraft, flights and formations required to attack all of the target types specified by the user.

(2) Match each air base to the closest attack corridor and calculate the number of aircraft (by type) available on each base. Determine the total number of aircraft available to assemble flights and formations.

(3) If the potential target is acceptable, an available formation is assigned to attack it in the current wave. If it is not acceptable, step (1) is repeated and a new potential target is examined for geographic suitability.

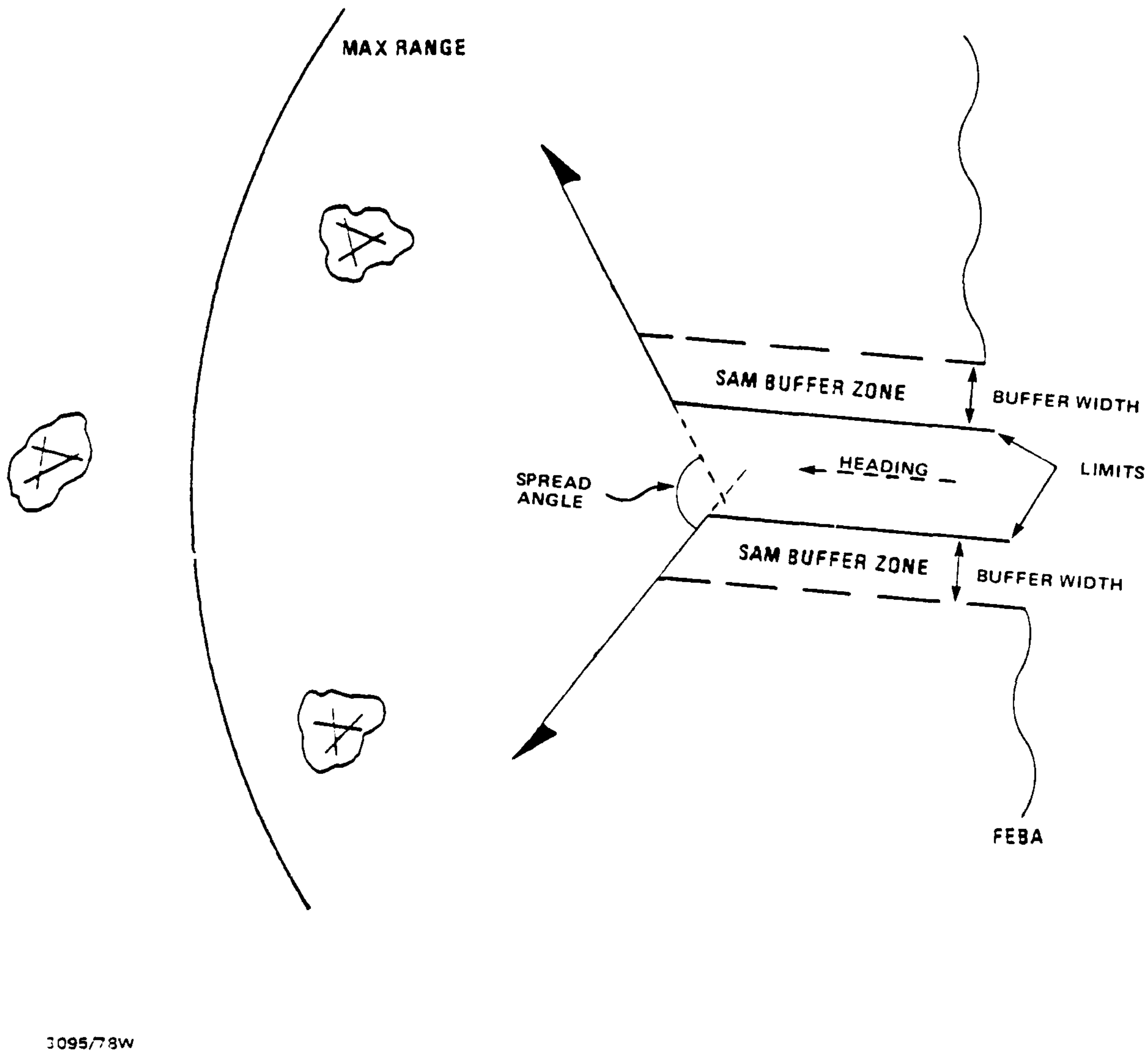

Figure IV-10. Corridor Specifications

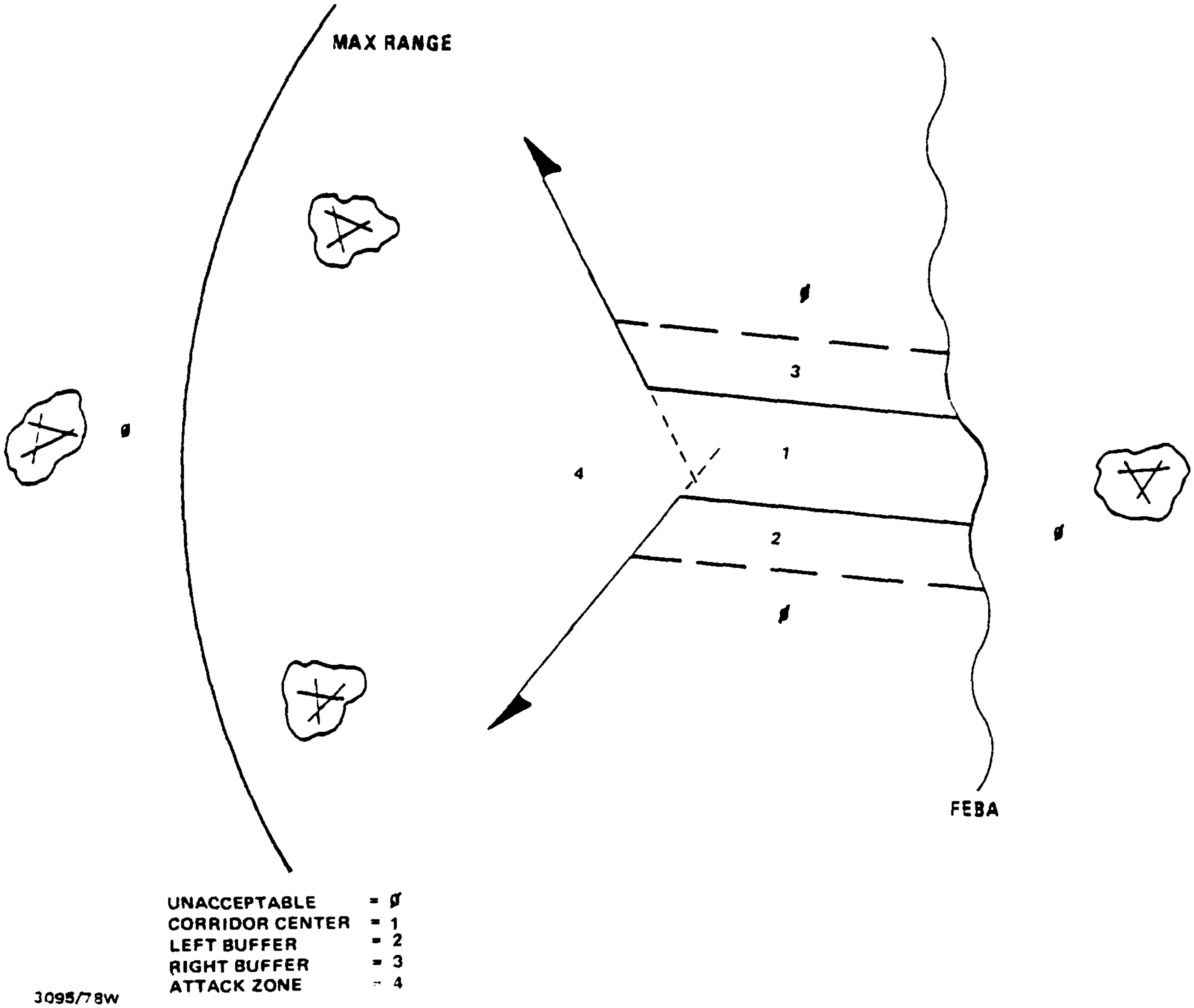

Figure IV-11. Corridor Zones

Execution of these three steps for all available formations results in a list of formation to target assignments, each formation is then assembled from flights launched from the airbases. Although all of the flights in a formation are assigned to attack the same target, their individual mission profiles may vary considerably. This variation is particularly pronounced for flights originating at different airbases which must rendevous to form a formation. The process of flights and their corresponding mission profiles is carried out in the Flight Scheduling Stage.

d. Flight Scheduling

Flight scheduling is the last stage in the Red Threat Planning Process. It is performed for each wave in the current raid and consists of generating a series of orders for each flight required to make up the formations specified in the target assignment stage. Flight scheduling is a two step process which may be summarized as follows:

(1) Determine the rendevous point for each formation. The rendezvous point is calculated as the center of gravity of the air bases weighted by the number of aircraft in the flights to be launched from each base.

(2) Construct a series of orders for each flight which instruct it on the actions to be carried out at specified locations. These orders cause the flight to climb to its rendezvous point, wait for other flights in the formation, proceed to the target through the corridor, carry out the attack and return to base. A flight profile of this type is shown in Figure IV-8. Altitudes at various phases in the mission are specified by the user in the flight data base.

(3) If a discrepancy exists between the required and available aircraft, the allocation of formation types to target types is proportionally adjusted accross target types until the actual number of formations assigned equals the number available.

Execution of these three steps results in a set of maximum aircraft allocations for each formation and target type. These maximum allocations are then used to guide the Target Assignment Stage.

e. Target Assignment

An assignment of formations to specific targets is made for each wave in the current raid. Assignments are made subject to the maximum allocation constraints which were calculated in the Overall Resource Allocation Stage. Target assignments are made in a three step process which considers formation type availability and target selection criteria. This process may be summarized as follows:

(1) For each available formation examine the perceived damage level of potential Blue targets. Potential targets are stratified by types which are matched to formation types specified by the user. The number of formations available by type has already been determined in the resource allocation stage. Only targets of the proper type are examined.

(2) Select the least damaged potential target and determine its geographic suitability. Suitability is determined relative to the closest attack corridor and the Red air bases to which the corridor has been matched in the resource allocation stage. In order to be acceptable, a potential target must be within minimum and maximum range and be located within the corridor zones set in the corridor boundary specification stage. (see figure C-8).

Execution of these steps for each formation which has an assigned target completes the four stage planning process. All flights now have their orders and are ready to carry out the raid without further intervention from the plan module.

2. Aircraft Movement

a. Terrain Representation

The aircraft movement process in MADEM is the principal driver of simulation events; once an attack is set in motion, the dynamic parallel/serial reactions of defenders are scheduled based primarily on events related to the position and movement of penetrating aircraft. Terrain in MADEM is represented on a discrete, two dimensional geographic coordinate system whose points represent centers of hexagonal regions. The lowest level (smallest) hexes currently represented in MADEM are 9.45 km

from center to center; this is the basic resolution or level of uncertainty in the actual position of aircraft. Appendix A discusses the hex coordinate system in more detail. Aircraft altitude in MADEM is represented on a continous coordinate defined from local terrain altitude; local terrain altitude is currently defined for second level hexes, which are 25 km from center to center. The choice of terrain resolution has to date been dictated by the objectives of minimizing memory requirements for model execution while retaining the capability to represent the entire central region of NATO's European theater. Figure IV-12 depicts the hex relationships of terrain representation and coordinates in MADEM.

b. Movement Mechanics

Aircraft movement takes place with 3 degrees of freedom; however, there is no representation of aerodynamic constraints on aircraft motion. Flight paths consist of straignt line segments from hex center to hex center; aircraft altitude changes are linear with respect to hexes traversed. Aircraft move at two nominal speeds in MADEM, "cruise" and "air combat"; both speeds are effective ground speeds and are user input for each flight type. Because of anisotropism introduced by hex topology, path lengths in the hex system are not necessarily equivalent to cartesion distances. Figure IV-13 shows an example; flight path A begins from the origin 0 and traverses 10 hexes, or 94.5 km in the hex coordinate system. Flight path B also terminates 94.5 km from the origin 0; however, flight path B traverses 12 hexes, or 113.4 km in the hex coordinate system. In order to deal with this problem, "hex" velocity for a flight of aircraft is increased by an amount directly proportional to the additional distance (if any) traveled in the hex coordinate system. For the example case in the figure, the nominal "cartesian" speed along flight path B is increased by (113.4/94.5) or a factor of 1.20.

c. Formation Structure

Aircraft movement in MADEM occurs for "formations" and "flights" of aircraft; formations can consist of multiple flights which in turn consist of one or more aircraft of a generic class. Four generic classes are represented: interceptors, (i.e., defensive air-air systems);

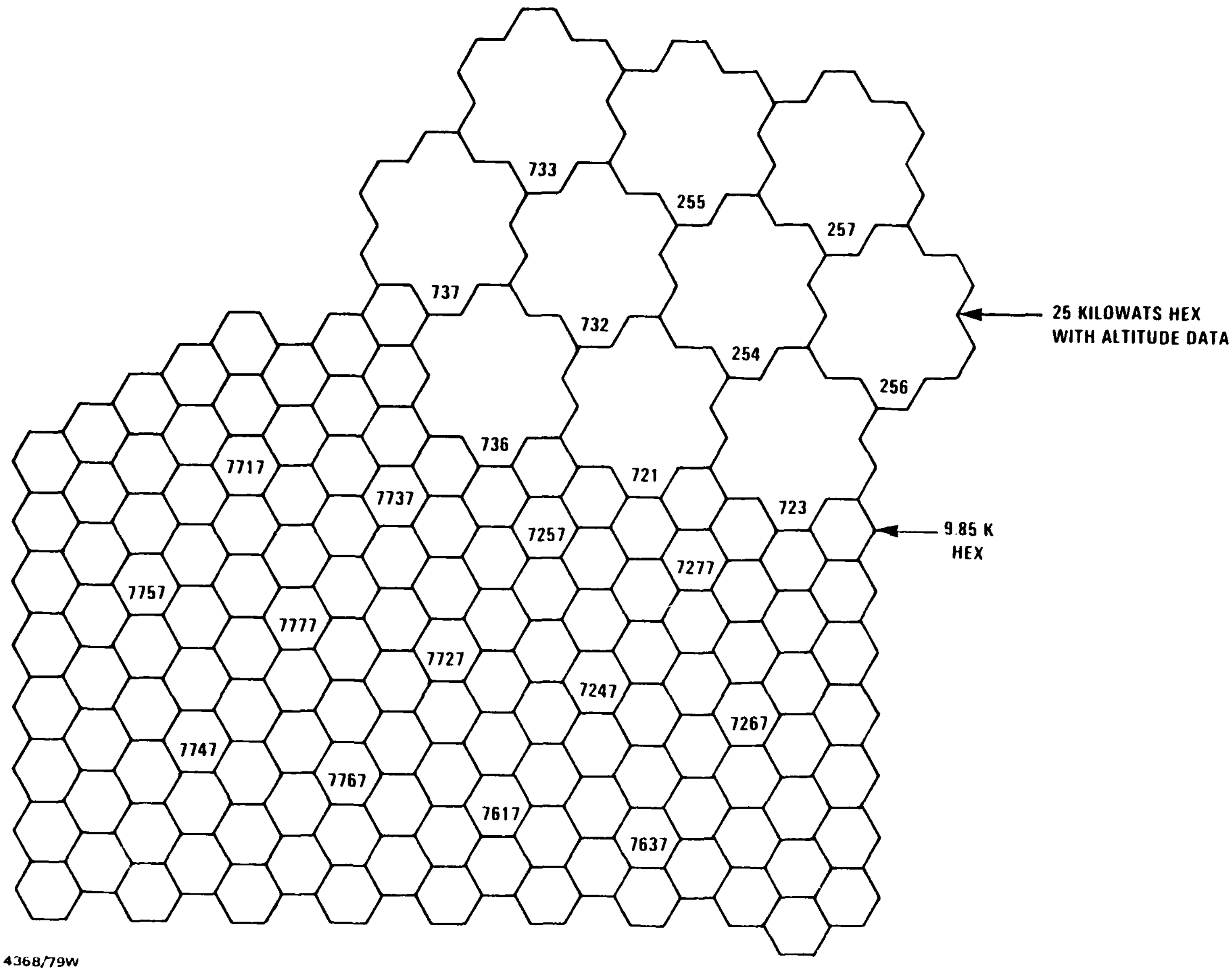

Figure IV-12. Terrain Representation

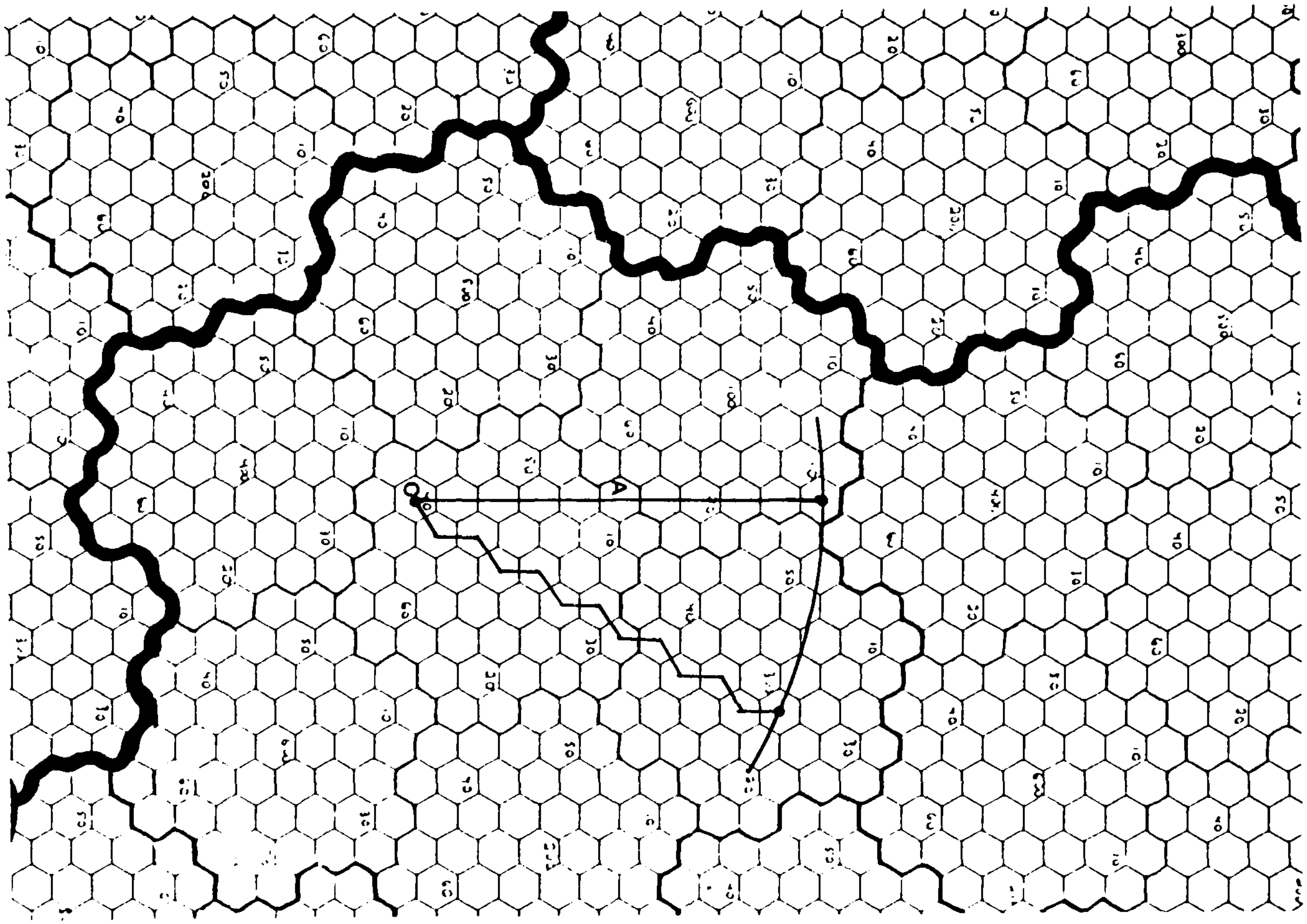

Figure IV-13. Flight Path Example

penetrating fighters with air-air capabilities; penetrating fighter-bombers with air-ground and optional air-air capabilities; and penetrating bombers with air-ground capabilities only. Up to twenty separate types of aircraft can be represented in each generic class.

Characteristics of aircraft movement processes differ somewhat between interceptors and offensive aircraft flights. Interceptor flight paths are based on orders from a CRC to a flight assigning either an orbit station near the CRC or a hostile flight to be engaged. Actual calculation of intercept points is treated in the discussion of air-air engagements; however, interceptor flights proceed from their present position to the calculated intercept point or orbit station by the most direct route from their present position. Interceptor flights do not form larger formations or maneuver in attacking an assigned target; for example, 2 flights assigned to the same target move independently to the calculated intercept point, as shown in Figure IV-14. Figure IV-14 also indicates the segments each flight would traverse in moving towards its objective.

d. Interceptor Characteristics

When interceptor flights are airborne but are not actively engaging hostile aircraft, they occupy orbit stations positioned near either their commanding CRC or their home air base. While interceptor aircraft are orbiting, they are assumed to remain in the designated orbit hex at a fixed altitude. Multiple flights are assumed to be able to occupy the same orbit station. CRC's position orbiting interceptor flights randomly within hexes adjacent to their location; air bases, when autonomous, orbit interceptors over their location.

e. Penetrator Characteristics

Penetrating fighters, fighter-bombers and bombers flight paths are all determined in the planning module. The planner generates a flight path consisting of a series of straight line "legs". Changes in heading and altitude are arbitrary between legs, allowing operationally realistic penetration profiles to be developed. Penetrator flights move on linear segments between hex centers in the same fashion as interceptors; however, the hex centers are chosen to minimize deviation from the flight

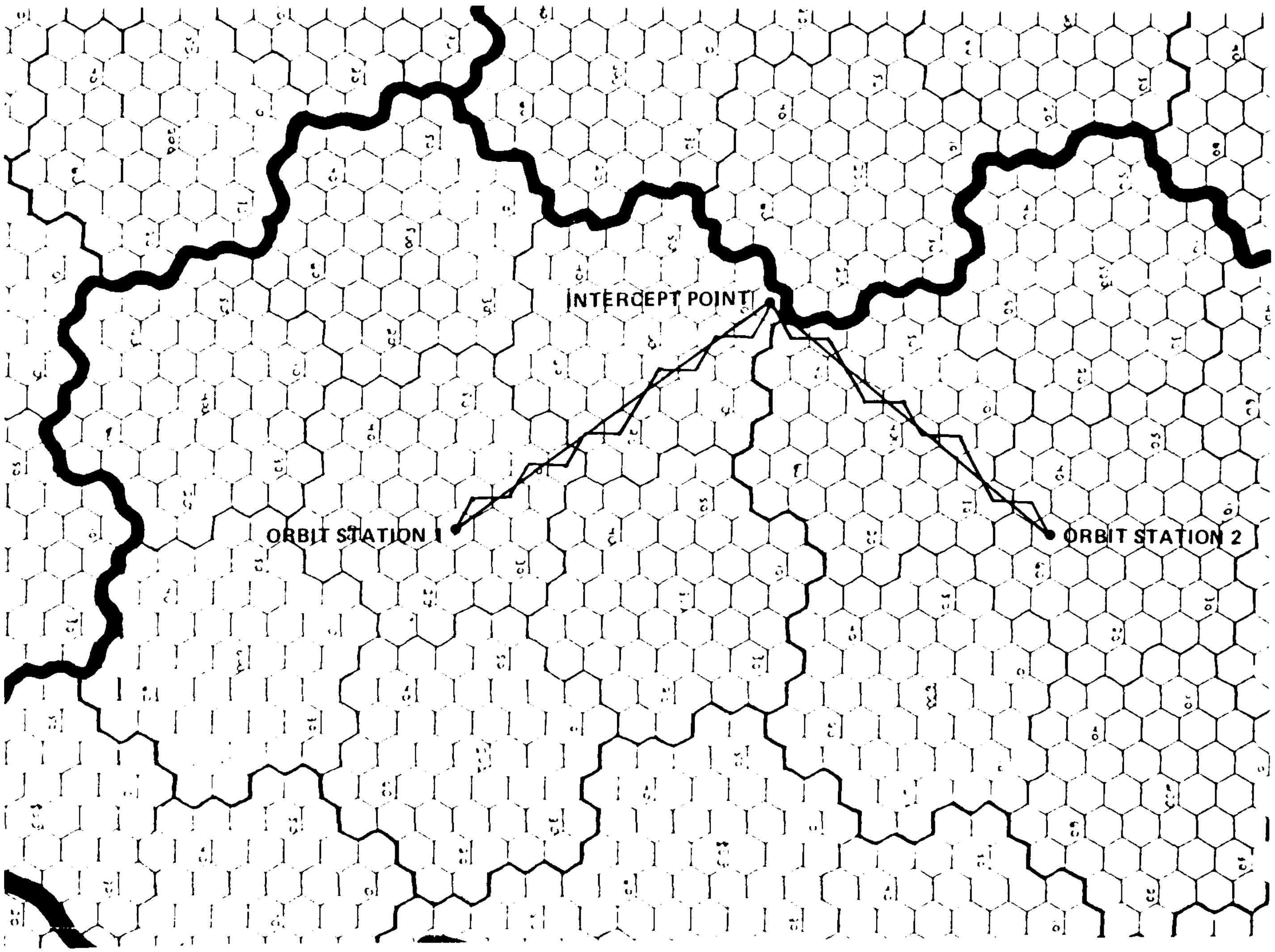

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Figure IV-14. Calculation of Interception Point

plan until the penetrator reaches its target. After surviving penetrators engage their targets they return to their air bases by the most direct route.

f. Movement Constraints

Flight movements for all aircraft types in MADEM are constrained by onboard fuel. Maximum operating ranges for each type aircraft are input by the user, and a continuous calculation is made of cumulative distance traversed by each flight. At the initiation of each flight movement, remaining fuel is compared against the distance to the flight's home base. If onboard fuel is less than 110% of the distance to the air base, or less than 3 hex equivalents, the flight attempts to return to its air base. If the flight is engaged by other aircraft while returning, it may expend all of its fuel and crash short of its airbase. Fuel consumption is assumed constant for all speeds and altitudes; however flights operating in the ground attack mode (e.g., fighter-bombers and bombers engaging their targets) are assessed twice the normal fuel to reflect terminal maneuvering for attack.

3. Threat Detection/Acquisition

Threat detection and tracking processes in MADEM are initiated by movements of both friendly and hostile flights of aircraft. Each movement of a flight to a new hex location invokes a search for all other players with the potential ability to see the new location of the flight. Each of these players is scheduled for an opportunity to detect the flight.

CRC's, BOC's and batteries can all perform threat detection. Each specific unit has one or more acquisition devices associated with it, corresponding to the acquisition and early warning radars assigned to the unit. All radars are assumed to be collocated with the unit, i.e., in the same 9.45 km hex; user specified maximum detection ranges for a nominal target and azimuth search sector limits (if any) are also specified for each radar.

Three basic conditions are necessary for detection to occur:

(1) The target flight must be inside the maximum detection range for at least one of the devices associated with a CRC, BOC or battery which can see to the location of the flight;

(2) The flight must be within the azimuthal scan sector for the device;

(3) Radar line-of-sight must exist from the acquisition device to the target.

In the event that a target flight and an acquisition unit occupy the same hex, immediate acquisition is assumed. Otherwise the maximum detection range for any device associated with the unit is considered. Figure IV-15 shows the probability of detection curve assumed for all devices in MADEM; for the region of the curve where detection is effectively a stochastic event (i.e., between 85% and 100% of the maximum detection range) a single replication MONTE CARLO process is modeled. For targets which are successfully detected, a test is made on azimuthal scan limits and detection events are nullified unless the target is located in the scan sector.

For cases where detection can occur given the above conditions, terrain masking to the acquisition unit is tested. The line of sight calculation assumes a curved earth and utilizes a value of 4/3 earth radius to account for radar propagation effects. Terrain masking angles are calculated for 25 km hexes along the line of sight from the detection radar site to the target; these are compared to the line of sight angle to determine whether masking exists. For units located in the same 25 km hex, line of sight is assumed to exist. Figure IV-16 shows a schematic example of the line of sight calculation.

Detection events in MADEM are essentially instantaneous and are scheduled to occur at the same time that a flight reaches the hex location initiating the detection event. In the nonautonomous (CRC) mode of operation, detections made by BOC's and batteries are passed instantaneously to the commanding CRC; BOC's operating autonomously conduct detection independently and also receive track information instantly from their subordinate batteries. In fully autonomous operation, all detections occur at the battery level.

In the CRC mode of control, IFF processing is assumed to occur at the CRC. For detections made by the CRC, perfect IFF is assumed. Detections made by the BOC's and batteries are passed to the CRC as hostiles;

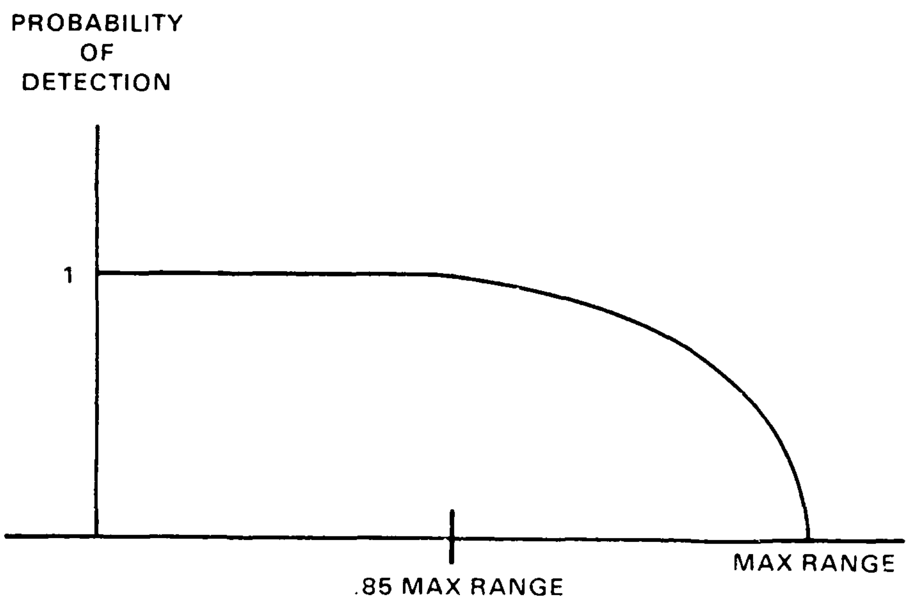

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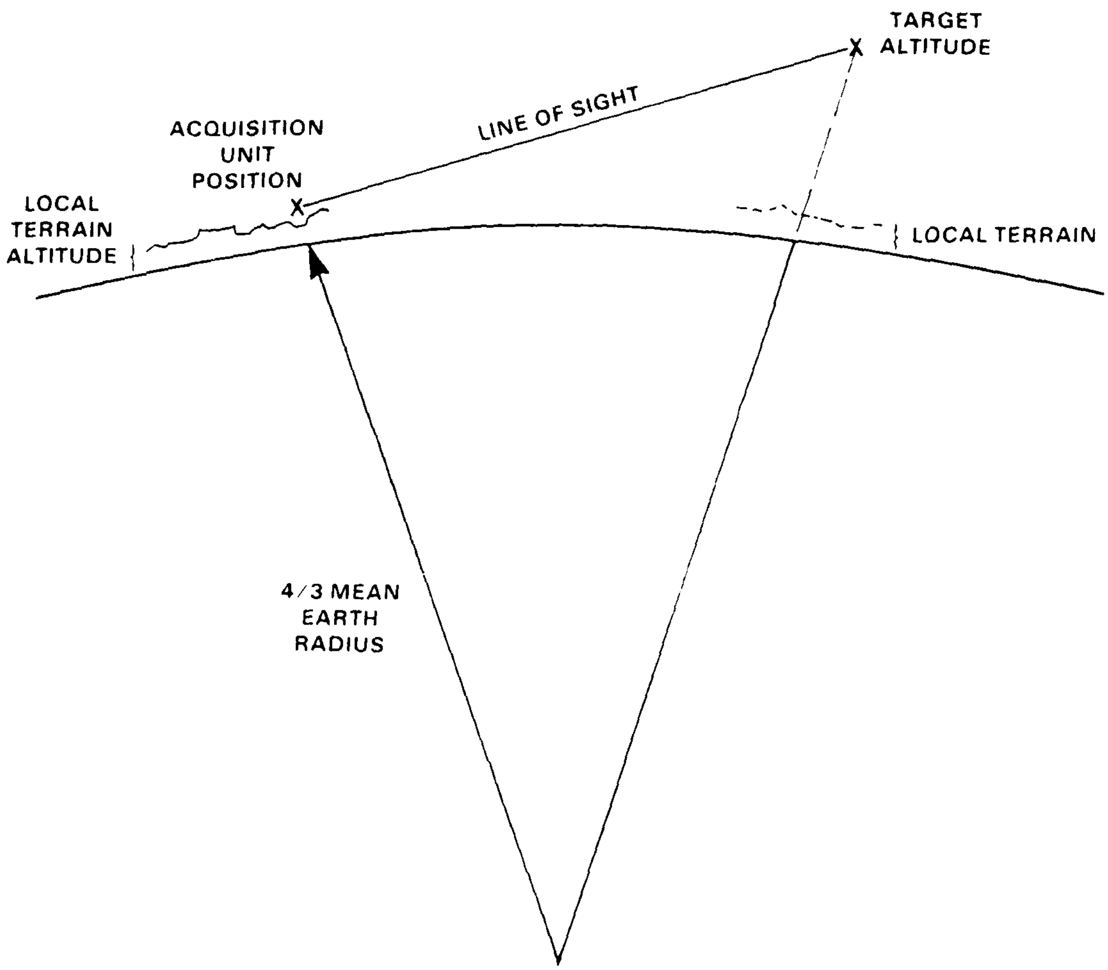
Figure IV-15. Probability Of Detection Curve



4368/79W

Figure IV-16. Line-Of-Sight Determination

the CRC then detects IFF errors of the type where hostile aircraft have been declared friendly with 90% probability. When operating autonomously, BOC's and batteries determine the identity of a flight based on a single replication MONTE CARLO process, with probability of correct identification equal to 97%. The identity of a flight is determined once for each continuous engagement of that flight; only flights identified as hostile are engaged.

4. Threat Allocation

a. CRC Threat Allocation

The CRC threat allocation processes may be triggered by any of the following events:

(1) CRC detection of a flight movement
(2) CRC detection of a flight death
(3) CRC receipt of a message from a BOC regarding a flight movement
(4) CRC receipt of a message from a BOC regarding a flight death
(5) CRC receipt of a message from an interceptor regarding the death of a red flight
(6) CRC receipt of a message from an interceptor regarding the availability of the interceptor.

The CRC first determines the direction of the Red flight. If the Red flight is returning home, it is marked nonavailable and no further attempts are made to assign either interceptors or SAM BOC's. If the Red flight is incoming, the CRC first attempts to assign the enemy flight to one of its airborne interceptors. If no interceptors are currently airborne, the air bases under the CRC's command are asked to scramble their available aircraft. If no aircraft are available the CRC attempts to assign a SAM battery. If an interception flight is airborne and not already assigned to a Red penetrator its ability (in terms of operational range) to intercept the enemy flight is determined. If it can intercept the enemy it is assigned to do so and the assignment process is terminated. If it cannot intercept the enemy and no other interceptor flights are airborne, the CRC attempts to assign a SAM BOC to the penetrator.

In attempting to assign a BOC to an incoming Red penetrator, the CRC considers the distance of the penetrator from the BOC, the altitude of the penetrator and the saturation limit of the BOC. The CRC checks all available BOC's to determine their distance from the penetrator. BOC's greater than 1000 km from the penetrator are dropped from consideration. The CRC then checks the saturation levels of the remaining candidate BOC's. BOC's with more than 30 enemy flights already assigned are dropped from further consideration. The altitude of the penetrator is then considered to determine the appropriate type of BOC for assignment. Penetrators flying above 3000 meters are assigned to the first available NIKE-HERCULES or PATRIOT BOC. Penetrators flying at or below 3000 meters are assigned to the first available HAWK or PATRIOT BOC. The assigned BOC then initiates its own penetrator assignment process to determine which of its subordinate batteries will be assigned to fire on the penetrators. If no BOC assignment can be made, the incoming penetrator is ignored until defensive assets become available.

b. BOC

Three types of battalion operations centers (BOC) are treated in MADEM -- Hawk, Nike Hercules, and Patriot. All types are treated in basically the same way. MADEM modeling for the threat allocation processes of a BOC is discussed below in terms of the treatment of the digestion of threat data, the tracking of the status of subordinate batteries, and the decision processes by which particular subordinates are selected to engage particular threats.

1) Digestion of Threat Data

The threat digestion process for a BOC involves all processing of threat data relevant to the unit's allocation decisions. Digestion of threat data is represented in MADEM in terms of cyclical attention to each member of a particular set of threats (or potential threats).

a) Basic Representation of Digestion Process

Associated with each BOC is a data structure called an Active Digested Information List (ADIL). The ADIL includes one

element for each threat currently in the set of threats under active consideration. The ADIL is basically a circular list of threats, and a pointer into the list indicates, at any time, the particular threat for which information is to be digested next -- i.e., the next threat to which the BOC is to pay explicit attention. It is upon the occurrence of a PONDER(DIGEST) event that data on the next threat to be considered is actually digested. The model assumes that each DIGEST event requires a certin minimum amount of time (MINTIMEDIGEST). Thus, successive DIGEST events for a particular BOC must be separated by at least this interval. The time required to digest information on all threats in the ADIL is then equal to the product of the number of threats in the ADIL and the minimum digest time. To prevent this cycle time from getting arbitrarily long, a limit (MAXNUMDIGEST) is imposed on the number of threats allowed in the ADIL at any particular time. Once the ADIL is full, additional threats which would otherwise be considered must be ignored until one of the threats currently in the ADIL is dropped for some reason. When the ADIL is not full, the time between successive DIGEST events may be greater than the minimum referenced above. In general, the model attempts to keep the digest cycle time at a specified value (MINCYCLEDIGEST). Subject to the limit imposed by the minimum digest time.

b) Inclusion of Threats in Digestion Cycle

Initially, a particular threat will be inserted into the ADIL for one of two reasons. If a BOC is under the command of a CRC, then only threats assigned to the BOC by the CRC will go into the ADIL. In this case, a threat inserted may not even be initially detectable by the BOC. The fact that the threat is in the ADIL will, however, enhance the chances of its detection when such detection becomes possible. For an assigned threat, the probability that the threat is detected, given it is potentially detectable, is 1.0. If a BOC is operating autonomously (i.e., not under the control of a CRC), then any detection of a threat, or potential threat, which is not already in the ADIL will result in immediate insertion of that threat. provided that the ADIL is not full.

For a BOC operating under CRC control, it is possible that more threats may be assigned than can be accommodated simultaneously in the ADIL. Threats assigned when the ADIL is full go into a Force Out Queue (FOQ) to await the opening of space in the ADIL. When such an opening arises, the top item on the FOQ is inserted.

A final way in which threats are inserted into the ADIL involves transfer from another list called the Passive Digested Information List (PDIL). A threat is moved from the ADIL to the PDIL when the BOC has allocated the desired level of coverage against it by assigning it to one or more subordinate batteries. The BOC pays no explicit attention to threats on the PDIL, since responsibility for these threats has been transferred to subordinates. Should one of these subordinates report a significant change in the threat, or should one or more of them report inability to engage the threat, then a resumption of consideration of the threat by the BOC is indicated. In such a case, an attempt is made to return the threat from PDIL to ADIL. If the ADIL is not full, there is no problem. If it is full, then the considered threat may go temporarily to the FOQ, or some low-priority threat currently in the ADIL may be transferred to the FOQ to make room.

c) <u>Elimination of Threats from Digestion Cycle</u>

A particular threat may be eleminated from the ADIL for any of a number of reasons, some already referred to. If an assigned threat is inserted into the ADIL before it is actually detectable by the BOC (or its subordinates), it will remain there only 120 seconds if not detected. When an assigned threat is ejected in this fashion, a message is sent to the CRC rejecting the assignment.

A threat may also be ejected from the ADIL as the result of a determination that it is not projected to be engageable by any of the BOC's subordinates. Such ejection by a nonautonomous BOC is again accompanied by an assignment rejection message to the CRC. A threat so ejected by an autonomous BOC might well reenter the ADIL upon its next movement (assuming detection), but in the meantime the ADIL space would be available for the entry of other possible engageable threats.

A threat once detected but then lost to sight may also be ejected from the ADIL if not redetected sufficiently soon. At each DIGEST event, the time of the latest detected information on the considered threat is compared to the time of the last-digested data. If the two times differ, then new data is available for digestion; if not, then either the old data will be retained and the threat checked again on the next digest cycle, or the threat will be ejected from the ADIL. Ejection is indicated if the last digested information is older than a specified threshold (LOSTTIME).

Since an autonomous BOC will insert any detectable flight into the ADIL if there is room, both RED and BLUE flights may appear in the list. If digestion of data on a particular threat leads to a conclusion that the considered flight is BLUE, then that flight will be considered non-threatening and will be ejected from the ADIL.

d) Nature of Basic Information Digested

As noted in a previous section, calculations to determine the detectability of a particular flight are carried out in connection with PERCEPT events coinciding in time with FLY events for the flight. The results of each such determination are then assumed to hold until the time of the flight's next FLY event. Thus, when a particular flight is considered in a DIGEST event, the outcome of that event depends on the results of the most recent PERCEPT events involving the flight and the BOC and its subordinate batteries. When the subject flight of the DIGEST is detectable, three types of data may be obtained regarding the flight--its nature as friend or foe, its course, and its size. In the case of a nonautonomous BOC, all considered flights are assumed to be RED. The BOC simply goes along with the CRC's prior assessment of the flight as foe. A BOC operating autonomously, however, must make its own determination. This determination is not made on every digest event, but only on those which involve the initial digestion of data on a new ADIL entry. So long as a flight remains in the ADIL, it retains its original characterization. Each time a particular threat reenters the ADIL after ejection, its identity as friend or foe is determined anew. On each such determination,

the model assumes a 0.03 probability that an error will occur. Thus, it is possible that certain BLUE flights may be assigned for engagement, while certain RED flights are erroneously rejected as targets.

Digested data on the course of a considered flight reflects the hex position of the flight at the time of its last FLY event, along with the flight's current heading and speed. Due to the fact that the flight's movement on the MADEM hex grid only approximate the actual assumed straight-line flight path legs, the actual projected course resulting from a digest event may vary somewhat from the actual assumed course. Any error present, however, appears only as a displacement of the calculated course from that assumed in a direction perpendicular to the flight heading. The maximum such displacement is half of a 9.45 km hex diameter, which is the same as the uncertainty for the ground unit locations.

The size-of-flight data derived from a DIGEST event reflects the actual current number of aircraft in the flight.

e) Processing of Basic Digested Information

Since the real purpose of the digestion process is to support the BOC's allocation decision processes, the basic data on threat course and size discussed above is transformed into direct inputs for these processes. These inputs are of three types -- projected engagement windows, threat priorities, and desired coverage levels.

1. Engagement Windows

During the course of the simulation, lists of projected engagement windows are maintained for each BOC. Each BOC has an individual list associated with each flight under consideration, as well as an individual list associated with each surviving subordinate battery. Such lists may be created, updated, and destroyed as part of the overall digestion process. Whenever new threat heading or speed data is digested for a particular threat, the set of engagement windows implied by this course data is also determined, and this data goes into a new list of windows for the considered threat. The data is also used to update window

lists for the individual batteries. Any engagement windows based on previous (now superseded) course data for the considered threat are eliminated.

Individual engagement windows are generated by calculating times of entry into and exit from the engagement areas of individual subordinates. For Hawk and Nike Hercules systems, engagement areas are assumed to be circular. The area for a particular battery is centered at the battery location and has a specified radius (MISSILERANGE). For Patriot batteries (firing sections), the engagement area has the shape of a circular wedge, with the tip of the wedge at the battery location. The total shape of the wedge is determined by a specified radius (MISSILERANGE), a specified center line (primary target line) orientation, and the angular width (^{o}) of the wedge. In the actual windows opening and closing calculations, allowance is made for the lead time in firing required to achieve intercept at the points of entry into and exit from the engagement area. Thus, the window's limits generated are limits on <u>firing time</u>, rather than on intercept time. In making the firing time calculations, the nominal flyout speed of the missile (MISSILERANGE/TIMEFLIGHT) is employed. A projected window of less than a specified time length (ENGAGEWINDOW) is treated as no window at all.

The calculation of projected engagement windows involves no consideration of the altitude of the considered flight. The CRC considers threat altitude in assigning targets, and the battery units consider altitude after achieving track on threats, but the BOC does <u>not</u> consider threat altitude at all.

2. Threat Priority

A BOC assigns priorities to considered threats on the basis of their headings and the times of the latest projected opportunities to engage them. The prime determinant is heading. Three priority categories are defined as follows:

Category 1 - threats with headings 45^{o} or less off of due west

Category 2	-	threats with headings between 45° and 90° off due west
Category 3	-	all other (eastbound) threats

Within each category, threats are ranked in order of the times of last engagement opportunity. Those threats for which the opportunity to engage will pass most quickly are given highest priority.

3. Desired Coverage

On the basis of the number of aircraft included in a particular flight, a BOC determines the level of coverage appropriate. Level of coverage is measured in terms of the number of simultaneous independent engagements to be carried on against the member aircraft of the flight. Included in the MADEM data base for each BOC type are desired coverage levels for flights of one (COVONONE), of "few" (COVONFEW), and of "many" (COVONMANY) aircraft. Also included is the specified dividing line (FEW) between "few" and "many".

2) Tracking of Subordinate Status

In situations in which a BOC has the option of assigning a given threat to any of a number of subordinate batteries, the decision as to which battery in particular should receive the assignment is based on the current levels of readiness of the individual batteries and on the load already imposed on each. A BOC's perception of the status of a particular battery is based on an initial knowledge of its status, updated during the course of the simulation on the basis of assignments made to and messages received from the battery.

a) Initial Status Data

At the outset of the simulation, a BOC knows the (constant) location of each battery, the total number of rounds of ammunition, and the maximum number of independent concurrent engagements which the battery can carry on. While the total number of rounds is known for each battery, the breakdown of this ammunition by type (conventional,

low-yield nuclear, high-yield nuclear) is _not_ known for those system types where a mix of types is allowed.

b) Updating of Status Data

During the course of the simulation a battery may send a variety of messages to its superior BOC. Some types carry specific status information on the battery itself, while others carry information on the status of a current assignment of the battery.

At the time of each missile firing, a battery sends a message which indicates the number of rounds expended, and also indicates any reduction in the number of independent concurrent engagements the battery can support. For example, if a firing exhausted the ammunition for one of the two fire units of a Hawk battery, the firing report would indicate a reduction of one in the engagement capacity of the battery. A message is also sent to the BOC when new ammunition becomes available to the battery in connection with a RESUPPLY/RELOAD event. This message is effectively the inverse of the firing report, in that it indicates rounds added and engagement capacity added, if any.

With regard to a particular assigned target, a battery may send messages indicating the effective end of the assignment. Such messages may indicate either a successful termination, due to destruction of the target, or an unsuccessful one, due to closing of the engagement window. In either case, such messages report a lightening of the current assignment load on the battery. Batteries also report the destruction of individual aircraft within flights, so that BOC's may reassess the coverage level appropriate for the diminished flight.

A battery may also send a message to its commander the effect of which is to cause the BOC to check on a particular target to determine if its assignment to the reporting battery is still justified. Such a message is sent when an assigned target is not sighted as expected, or when it is initially detected but subsequently lost to sight. When an assigned target is observed to deviate significantly from the course indicated by the BOC in the original target assignment order, a similar message is sent. In this case, however, the message is intended more to

make the BOC aware of the possibility of new engagement opportunities for other batteries than to indicate any important change in the status of the reporting battery itself. In an instance in which the course change was so dramatic as to preclude the battery from engaging the target, the battery would simply report a closing of the engagement window.

3) Assignment of threats to batteries

The basic goal of each BOC player in the MADEM simulation is to see that an appropriate level of coverage is maintained on each considered threat at all times. A BOC achieves this coverage by assigning the threat to one or more subordinate batteries. Decisions as to which threats will be assigned to which subordinates, and when, are made on the basis of the digested threat data and subordinate status information discussed above. There are three basic situations in which a BOC in MADEM may make a threat assignment. One of these involves the consideration of a particular threat which is not sufficiently covered. Another involves the consideration of a particular subordinate with currently idle engagement capacity. The third involves the opening of an engagement window involving a particular threat and battery combination. The nature of the assignment decision in each situation will be discussed in turn, and instances in which a battery may be ordered to reduce its coverage of a threat will then be discussed.

a) Selection of Battery(s) to Cover a Threat

There are a number of circumstances under which a BOC in MADEM will seek a particular battery, or batteries, to which a particular considered threat can be assigned. Some of these circumstances arise in the threat data digestion process, while others arise from the processing of reports from subordinates.

When a particular threat is initially considered in the digestion process, and engagement windows are projected as a result, the BOC will make its initial attempt to cover (assign) the threat. Also, when digestion of new information on a previously considered threat indicates a course change resulting in new engagement opportunities, an attempt to assign new coverage may occur.

The above circumstances under which there may be an attempt to assign a threat relate basically to the realization of new engagement opportunities. Attempts to assign may also arise out of the realization of the ends of previously projected opportunities. In such a case, the spur to the assignment attempt will be a report from some subordinate to which the considered threat was previously assigned. A subordinate might, for example, report the closing of its engagement window against an assigned threat. In such a case, another subordinate must be sought to replace the lost coverage on the particular threat considered. Alternatively, a battery might report its total disablement by air-to-ground attack. In tnis case, alternative coverage must be sought for all of the threats currently assigned to the disabled subordinate. A battery might also report a decrease in engagement capacity due to ammunition expenditure. Such a decrease would imply a decrease in the maximum allowable load for the battery. In a situation in which the battery's current load exceeds the new allowable maximum, the load is reduced by cancelling one or more of the current assignments. There is then a need to seek other batteries to which assignments can be made to compensate for the lost coverage.

A particular battery, or set of batteries, is selected to engage a considered threat on the basis of the following:

(1) timing of projected engagement windows
(2) current engagement capacities of batteries
(3) current loads on batteries
(4) current ammunition stocks of batteries.

Only batteries for which a projected engagement window against the threat is currently open, or will open within two minutes, are considered as candidates for assignment to the considered threat. Also, only batteries which do not already have a full assignment load are considered. These batteries, if any, which satisfy the above criteria are divided among the following three perference categores:

(1) batteries for which there is adequate response time, and for which the current engagement capacity exceeds the current engagement load

(2) batteries for which there is adequate response time, but for which current engagement capacity does not exceed the current engagement load

(3) batteries for which there is minimal time to respond, and for which the current engagement capacity exceeds the current engagement load

Response time adequacy is determined by the closing time of the relevant engagement window. If the time between the assignment decision and the projected closing of the window does not exceed a specified threshold (LOWRESPTIME), the likelihood that the battery involved could successfully respond to an assignment order is assumed to be low. Thus, preference is given to assignments where the projected time to respond is adequate. A secondary preference is given to batteries which can immediately undertake engagement could be supported concurrently with those against any already assigned targets. It may be noted that the above listed preference categories do not cover all assignment candidates as defined above. Those for which there is minimal response time and for which the battery could not support another independent engagement immediately are eliminated from consideration.

Within each of the three general preference categories defined above, individual batteries are ranked in order of ammunition available minus engagement load. Batteries are selected for assignment in accordance with the indicated preference order until the desired level of coverage has been achieved against the considered threat, or until all currently possible assignments of the threat have been made. A particular battery selected to engage the threat may be assigned to provide more than one unit of coverage (independent engagement) on the threat. Such coverage will be ordered if called for by the size of the threat and made possible by the engagement capacity of the battery.

b) <u>Selection of Threat(s) to be Covered by a Battery</u>

A perceived change in the status of a particular subordinate may give a BOC reason to seek some new assignment(s) for that subordinate. For example, a report from a battery indicating the activation of new engagement capacity due to ammunition resupply will occasion

such a search. Similarly, a reduction of the load on a battery may be reason to seek new assignments to make maximal use of the battery. Such a load reduction may result from the end of a previous engagement, or from a reduction in the assigned coverage level against some threat.

When assignments are to be sought for a particular threat, only those threats which are in the BOC's active digested information list and which do not have the desired level of coverage assigned are considered. Such threats for which the considered battery has open, or soon to open, projected engagement windows are split between two preference categories:

(1) threats for which the battery has adequate projected response time

(2) threats for which the battery has minimal projected response time.

Again, response time adequacy is based on the time to the projected window closing for the threat; if this time exceeds a threshold (LOWRESPTIME), there is assumed to be adequate time for the battery to respond to an engagement order. Within each category, individual threats are ranked in order of their assigned priorities. Tracks are selected for assignment to the battery, in accordance with the discussed preference order, until the battery is fully loaded, or until all allowed assignments have been made. If a threat is selected for which the current coverage shortfall is greater than one, then the battery may be assigned more than one unit of coverage on the threat, assuming that it is capable of simultaneous, independent engagement of members of the threat flight.

c) <u>Consideration of Projected Window Openings</u>

As indicated previously, a BOC in MADEM will not assign a threat to a battery more than two minutes in advance of the projected opening of the relevant engagement window. Thus, some projected engagement windows cannot be used as bases for assignment decisions until some time has passed after their generation by the process of threat data digestion. When a window is projected which cannot be used immediately, an event is scheduled to occur in the simulation at the time at which the BOC

could first make an assignment decision on the basis of the projection. The occurrence of this event (called an OPPORTUNITY KNOCKS event) causes the BOC to consider assigning the threat involved to the battery involved. Such an assignment will occur if the threat is not already fully covered, and the battery is not already fully loaded.

d) Reduction in Battery Assignments

A BOC may decide to reduce the assignment load of a battery for either of two basic reasons. The first of these reasons is a decrease in perceived size of an assigned threat. A BOC may become aware of attrition of a flight either through its own digestion process or through reports from its subordinates. When a change is noted which implies a change in the level of coverage appropriate for the threat (i.e., a change from "many" to "few" or a change from "few" to one), the BOC can reduce the coverage by cancelling an assignment, or by reducing the coverage level associated with a particular assignment. When a choice is to be made regarding which battery should have its load reduced in connection with a coverage reduction, the candidate with the least ammunition surplus (ammunition stock minus load) is selected.

The second reason for reducing the assignment load on a battery is a decrease in the engagement capacity of the battery. Since the maximum allowable load for a battery is calculated as a multiple (MAXASSIGN) of the current engagement capacity, a decrease in this capacity may leave the battery overloaded. In such an instance, the BOC relieves the battery of some of its assignments. Assignments are cancelled, as necessary, in reverse order of the priorities of the threats involved.

c. Battery

Three types of SAM batteries are treated in MADEM -- Hawk, Nike Hercules, and Patriot. Many aspects of the modeling of threat allocation processes in MADEM are common for all three battery types. The major differences among modeling for the three relates to the treatment of engagement capacity for a battery. A Hawk battery is treated as two distinct fire units. Each fire unit has its own ammunition supply, and the two fire units can engage separate targets independently. When a fire unit

runs out of ammunition, the engagement capacity of the battery is decreased by one. A Nike Hercules battery is treated as a single fire unit; thus, the engagement capacity of such a unit is always one, so long as ammunition remains. A Patriot battery player, which actually more nearly represents a Patriot firing section, is treated as a single unit with a capacity for multiple simultaneous independent engagements, all of which draw upon the common ammunition supply associated with the unit. The maximum number of simultaneous engagements allowed to such a unit is subject to the constraint that there must be at least one missile committed to each engagement in progress at any given time.

The discussion of the threat allocation process for batteries which follows will be similar in form to the previous discussion of such processes for BOC's. Digestion of threat data will be treated first. The tracking of fire unit (engagement capacity) status will then be touched upon. Finally, the decision processes by which particular threats are selected for engagement by particular fire units will be discussed.

The threat digestion process for a battery in MADEM involves all processing of threat data relevant to the unit's engagement decisions. The basic nature of the digestion process is identical to that discussed earlier in connection with BOC's.

The battery maintains an Active Digested Information List (ADIL) equivalent to that maintained by a BOC. For a nonautonomous battery, only threats assigned by the commanding BOC are entered in the ADIL for processing. For an autonomous battery, all detectable threats go into the ADIL, so long as the ADIL is not filled to capacity. Each battery also has a Force Out Queue (FOQ) which serves the same function as for a BOC. A battery does not have a Passive Digested Information List (PDIL), since a battery has no subordinates to which it can pass off threats. Each battery does, however have a corresponding structure called the tracked list. Threats are moved to this list from the ADIL when tracking of the threat is initiated as part of an actual engagement. Threats on the tracked list are effectively under continuous scrutiny. New information is digested on such a threat immediately each time it moves; there is no wait for the threat to be reached in the normal cycle through the ADIL.

A significant difference between ADIL entries for BOC's and batteries is that assigned threats have associated course data when initially added to the ADIL by batteries. This data is passed to the battery by the BOC. No such data is passed from CRC to BOC. After a battery initially digests data on an assigned threat, it can detect any course change which has taken place since the BOC's last digestion of data on the threat prior to its decision to assign. This allows the battery to report such changes to the BOC, so that the BOC might reassess its previous decisions.

The particular threat data digested by batteries -- flight "side", course, and size -- is identical to that for BOC's. Like BOC's, batteries assume assigned threats to be RED. Confusion of the loyality of unassigned threats is handled similarly.

For an autonomous battery, the basic outputs of the digestion process are the same as for BOC's -- engagement windows, threat priorities, and desired coverage levels. For a battery under command of a BOC, however, the desired coverage level for each threat is specified by the assignment order. This level can be changed only by further orders from the BOC.

A battery calculates engagement windows for itself in the same manner as a BOC does for each of its subordinates. Should a battery's window determination indicate that no window for an assigned threat -- perhaps due to course change, or to insufficient response time -- the battery will report a window closing to its BOC and give up on the assignment.

A non-autonomous battery assigns priorities to threats in the same manner as does a BOC, on the basis of heading and last opportunity (of the considered battery only) to engage. Priority assignment by autonomous batteries is basically similar, but differs in the precise manner in which threat heading is treated. Instead of assigning highest priority to threats whose headings are within 45° of due west, an autonomous battery gives top priority to threats with headings within 45° of a direction specified for the individual unit. Each battery has a Primary

Target Line (PTL) defined in terms of a heading from the units position. Flights approaching from the direction of the primary target line are given top priority. Second and third priority categories are defined as before, but with the role of due-west being taken by the heading PTL+180°.

For autonomous batteries, the determination of the coverage level appropriate for a threat is carried out just as for a BOC. The coverage levels appropriate for one, few, and many may be different, however, from those accessed by the BOC, since the data used by the battery is accessed from a battery type data base instead of from the BOC type data base. The battery type data base should not indicate, for any size flight, a desired coverage greater than the maximum engagement capacity of the battery.

The basic goal of each battery player in the MADEM simulation is to see that an appropriate level of coverage is maintained on each considered threat at all times. A battery seeks to achieve this goal by allocating appropriate firepower against each threat. In the case of a Nike Hercules battery, there is not question of which firepower should be allocated, since there is only one fire unit available. The case of a Patriot battery is basically similar, in that all firepower is assumed to be allocated from a single common pool. In the case of a Hawk battery, however, two fire units are represented as distinct entities. A separate ammunition stock is tracked for each, and there is, thus, a basis for selecting a particular fire unit for a given engagement.

Decisions resulting in the allocation of firepower to particular threats are made in two basic situations. One of these involves the consideration of a particular threat which is not adequately covered. The other involves the consideration of newly idle firepower.

A battery may decide to allocate firepower against a threat at the time at which the threat is initially considered in the digestion process. This will happen if an engagement window of significant length is projected and idle firepower is available. Also, firepower may be allocated against a threat as the result of new window projections generated during subsequent treatments of the threat in the digestion

process. Firepower is to be allocated in order of available ammunition, in order to keep both fire units operational for as long as possible.

Whenever new firepower becomes available, a battery will seek a threat (or threats) to occupy that firepower. New firepower may become available as the result of an engagement ending, or as the result of a RESUPPLY/RELOAD event for the battery. Threats for engagement are chosen from among those with currently projected engagement windows, in accordance with threat priority.

Just as BOC's may decide that subordinate batteries should reduce coverage levels on certain threats, so also may autonomous batteries decide to reduce coverage. Thus, for example, an autonomous Hawk battery might start out engaging a flight of "few" aircraft with both fire units, but continue the engagement with just one fire unit when the target had been attrited to just one aircraft. When a Hawk battery does engage a single flight with both fire units, it will cease fire first with the fire unit with less ammunition.

d. Interceptors

Interceptors are normally vectored to intercept incoming penetrator flights by their commanding CRC. However, interceptors will also engage penetrators which pass within one hex (9.45 km) of their flight paths. After each engagement, surviving interceptor flights request orders from their CRC. If the CRC is still alive and able to communicate, interceptors with sufficient fuel remaining will be assigned to new target penetrators. Interceptors with insufficient fuel will return to their respective airbases.

When an interceptor's commanding CRC has been destroyed or cannot communicate, the interceptor returns to its airbase and assumes a CAP orbit until it must land for refueling. Any penetrators encountered on the return flight will be engaged by the interceptor if its fuel level allows. If it has insufficient fuel it will attempt to disengage and retreat to its air base.

e. Air Bases

Under normal conditions blue airbases launch interceptors only in response to orders from their commanding CRC. However, if their CRC is destroyed air bases will launch interceptors to fly defensive CAP orbits. These interceptors will defend the air bases by engaging any penetrators which close to within on hex (9.45 km) of the base.

5. Engagements

a. Air-Air Engagement

Air-air engagements in MADEM are treated in terms of salvo exchanges of user defined ordnance packages between flights of aircraft located in the same or adjacent hexes. Interceptors, fighters or fighter-bombers with a designated air-air capability all can engage airborne targets; up to 10 separate air-air ordnance types can be allocated to each generic air-air flight.

Target acquisition for air-air combat can occur in three ways. First, a hostile flight may move into the same hex or a hex adjacent to the one currently occupied by a flight. Second, a flight may move into a hex and perceive a hostile flight in the same or an adjacent hex. (Identification/ Friend or Foe is assumed to be perfect for airborne systems, i.e., visual identification before engagement is assumed.) Finally a flight may perceive that it is under attack by a hostile aircraft. After acquiring a hostile flight, an evaluation is made of the capability to carry out a successful attack.

Assuming that a flight is not actively engaging a target, it will engage any hostile flights encountered as long as air-air ordnance of any type and fuel remain available. An 11 second "reaction time" delay occurs between detection of a hostile flight and launching of ordnance. During this period, the attacking flight goes to aircombat speed; if the flight is an interceptor flight and if the detected hostile flight is not the target originally assigned by the CRC, a message is sent to the CRC indicating that a target of opportunity is being attacked. If the flight initiating the attack is a fighter-bomber flight, all air-ground ordnance is jettisoned before launching air-air ordnance.

The actual engagement process model for air-air combat consists of choosing an ordnance package from the remaining air-air ordnance remaining for the attacking flight; launching a salvo; and damage assessment. Ordnance packages are user defined weapons groupings to be launched simultaneously by each aircraft, e.g., 1 AIM-7 missile, 2 AIM-9 missiles, half second air-air gun bursts, etc. Ordnance packages are developed independently for each aircraft type, and thus are intended to reflect the ordnance compatibility of alternate aircraft, as well as expected tactics and firing doctrine. Ordnance packages are chosen based on a fixed priority developed for each aircraft type; lower priority packages are not employed until all higher priority packages have been expended.

After the applicable ordnance package has been chosen, each aircraft in the attacking flight fires its ordnance package; total salvo size is thus dependent on the attacking flight size, as shown in the figure. Available ordnance for the flight is updated to reflect the expenditure of salvos independently for each flight.

All ordnance in a salvo is assumed to be launched simultaneously; attrition is based on a sequential, independent MONTE CARLO process employing user developed probability of kill (P_k) values for each ordnance package against a single aircraft. Currently, P_k values do not reflect alternate vulnerabilities for different aircraft types, dynamic degradation of weapon effectiveness of ECM, or changes in P_k as a function of differences in target vs. firing flight range and altitude. One MONTE CARLO replication is made for each ordnance package launched in a salvo, due to the large number of total engagements expected for typical model cases.

The primary result of the assumptions discussed above is that attacking aircraft do not engage target flights independently but sequentially, with the exception that an entire salvo is always expended, even if no targets remain for the final ordnance packages. For example, if a flight of four interceptors engages a flight composed of a single fighter, four ordnance packages are always launched, even for cases where

the nominal first, second, or third packages kill the aircraft. Damage assessment and kill removal is immediate in the model; no partial damage is considered. In the event that an interceptor entirely destroys its target flight, it sends a message to its commanding CRC (if the CRC is alive) indicating target destruction and availability for assignment to a new target. Penetrating flights which destroy their targets continue to their assigned targets from their present position unless they have expended all of their air-air munitions. Any flight which has expended all of its air-air munitions or has exhausted its combat fuel returns to its home air base.

After a salvo has been launched and the damage assessed, available ordnance for the attacking flight is updated. Three seconds after ordnance is launched, the flight under attack perceives that it has been attacked; survivors of the salvo have an opportunity to react. Flights with an air-air capability, remaining air-air ordnance and remaining fuel for air combat will respond to an attack by scheduling a counter attack, after an 11 second delay. Fighter-bombers without air-air capability, bombers, and any aircraft flight returning to its home airbase because of fuel or air-air ammunition depletion do not react to air attacks.

Once an air-air engagement is initiated, it continues until one of the following events occurs:

(1) The targeted flight evades the attacker;
(2) The targeted flight is destroyed;
(3) The attacking flight is destroyed;
(4) The attacking flight depletes its fuel or air-air ordnance and breaks off.

The major driver is a continuing engagement in movement of the flights. Scheduling of movement is based on flight speed and is independent of scheduling for aircombat events; thus, for example, a faster aircraft flight can rapidly evade a slower attacking flight. However, scheduling of aircombat events is coupled to movement; an attacking flight can fire only one salvo at a target flight unless it moves or fires a

retaliatory salvo. This feature is intended to prevent unconstrained firing of multiple salvos at low speed flights. In the event that an interceptor flight destroys its target or expends all of its fuel/air-air ordnance, it sends a status message to its commanding CRC. In the event the interceptor flight is destroyed, the CRC is immediately aware of the loss.

Offensive fighters and fighter-bomber flights engage only air-air targets of opportunity (i.e., interceptor flights) encountered while ingressing or egressing from their assigned targets. No attempt is made to portray offensive, hostile air superiority missions by the threat.

Interceptor flights operate under two modes of control, the CRC mode and autonomous mode. In the CRC mode, specific target flights are identified by the CRC, an attempt is made to assign airborne interceptor flights to these targets. The unassigned interceptor flight which is closest to the target and which has an intercept capability is assigned to the target. Only one interceptor flight is assigned against each target flight; no consideration is given to actual size of either interceptor or target flights. Since CRC's have imperfect IFF, the target flight may turn out to be friendly; in this event, the interceptor flight sends a message to the CRC indicating a friendly intercept/non-engagement, as discussed previously.

In the event that interceptors cannot be assigned (either because all airborne interceptors are assigned or because unassigned airborne interceptor flights cannot achieve or intercept) then an attempt will be made to assign ground-air assets against the target. A concurrent request will be made by the CRC to its subordinate air bases to launch available interceptors. Currently, CRC's hold their subordinate interceptor assets autonomously.

Intercept calculations are based on the low of cosines, assuming that the CRC has instantaneous heading and velocity (track) information at the time an intercept assignment is made, and also assuming that the target flight will maintain its heading and speed. The required condition is that the time to intercept equal the flight time of the target

to the intercept point; this results in the equation derived in the figure. Once an interceptor flight has been assigned to a target by the CRC, a continuous recalculation is made of the intercept point, and the interceptor flies to the intercept point continuously. The intercept assignment is dropped if intercept fails to remain feasible.

Interceptors may engage targets of opportunity whenever they are encountered, either in the course of an intercept assignment before the intercept is made or while on orbit. In the autonomous mode, i.e., when the CRC is destroyed, all air-air engagements are against targets of opportunity which encounter interceptors on air patrol orbits near air bases.

b. Surface to Air Engagements

After an initial 30 second sighting delay for a new track, a CRC attempts to assign either interceptors or ground-air assets against the track. Details of the interceptor assignment process are discussed in the paragraph on air-air processes. When interceptors are not available for assignment, all BOC's with a nominal capability to see the current location of the target flight are searched. The primary criteria for assignment of a BOC to a track are:

(1) availability of the BOC to accept the assignment;

(2) range of the BOC to the target -- the closest available BOC is assigned;

(3) availability to the BOC's of batteries with an engagement capability at the altitude of the targets, i.e., only NIKE HERCULES BOC's are assigned to high altitude targets, and only HAWK BOC's are assigned to low altitude targets.

If a BOC is currently processing less than 30 tracks and is able to accept an assignment, the BOC processes the track; otherwise a message is sent to the CRC indicating that the BOC is not ready. In the event that actual line of sight does not exist to the target (due to stochastic detection events or terrain masking) the track is tagged as early warning information and an expected detection event is scheduled.

Tracking events are driven by flight movements in much the same way as detections. CRC's continue to track flights as it perceives each flight movement. Track data available to the CRC includes latest track update time; true flight heading in cartesion coordinates (i.e., not between low level hexes); true flight velocity and true flight altitude. At each track update, the CRC reviews the track assignment status. For targets which are viable (i.e., not east bound) and which are assigned to interceptors, new interception projections are made and messages sent to the assigned interceptor flight. There are no limitations to the track processing capacity of the CRC.

For tracks detected and perceived to be hostile by an autonomous BOC, or assigned by a CRC to a subordinate BOC, the BOC calculates a projected engagement window for each of its subordinate batteries against the track. Those batteries where an engagement window exists are put on a list for possible assignment against the track, and a priority is calculated for the track by the BOC. The track is then entered into a prioritized list of active tracks being processed by the BOC.

As each track is taken from the prioritized list, the list of batteries with a potential engagement window against the track is surveyed to determine which battery has the latest engagement opportunity, in order to determine when the last chance for engagement of the track by the BOC occurs. Batteries are assigned against the track in decreasing order of their associated ready ammunition until a user specified desired coverage level against the track has been met; the number of batteries required is in turn based on the actual number of ready fire units and available ammunition for each battery.

Currently only immediate (i.e., instantaneous) processing is played in MADEM; however the option exists of representing BOC and battery processing in terms of a single server queue with user specified processing times. This option has not been exercised to date. In the autonomous mode, the BOC assigns all of its resources to the highest priority tracks; if additional tracks are present, they penetrate without being engaged by the BOC.

For tracks detected by an autonomous battery, or assigned to a subordinate battery by a commanding BOC, the battery calculates an engagement window for the track. If an engagement window exists and it does not exceed a user specified threshold response time (i.e., a minimum required engagement window) the track is dropped. Otherwise, the battery places the track in a prioritized list of all active tracks which it is considering. It then assesses whether the assigned target can be tracked, considering existence of line of sight, and maximum tracking range for the battery, if any. For cases where tracking cannot occur, the target is dropped; otherwise the battery attempts to assign ready, available fire units against the track. For NIKE HERCULES and HAWK units, with capabilty for engagement of a single track at a time, fire units are allocated until user specified desired coverage against the track is achieved or until all resources are assigned. For systems such as Patriot, with capability for multiple simultaneous engagements, a running total of simultaneous engagement assignments is kept for the battery; engagements are assigned against a track until user specified desired coverage for the track is achieved or until all engagement capability is in use.

The basic processes discussed above proceed in parallel at the CRC, BOC and battery level as tracking of a target continues. As the target moves and changes direction, allocation of assets is shifted to reflect the changing conditions as a function of all of the other tracks in the region.

At each step of the tracking process - i.e., every time a target flight moves -- batteries tracking the target evaluate their engagement opportunity.

In considering an engagement attempt against a track, a battery evaluates the current target altitude, which is assumed to be available as part of the track data (i.e., height finding processes are not modeled). If the target altitude is not within user specified engagement limits, the engagement attempt is halted.

For cases where an engagement is possible, warhead types are chosen to be launched. Three generic systems are currently considered in

MADEM, representing HAWK, NIKE HERCULES and Patriot. HAWK fires only conventional ordnance; thus the only requirement is availability of ready ammunition. Nike Hercules is assumed to be able to utilize both "large" and "small" yield nuclear warheads and conventional warheads. The decision tree for munition choice is shown in figures IV-17 and IV-18. The user controls the total pool of munitions to be considered -- i.e., for a conventional only case, no nuclear munitions are specified in the initialization data. Patriot is assumed to have a capability to utilize both conventional and "small" yield nuclear warheads; the figure shows the decision tree for munition use by Patriot units. In the event that no appropriate munition is available, engagement is terminated.

Where engagement processing continues, the feasibility of an intercept is calculated. This involves calculating the projected intercept point, if one exists, and insuring that all engagements take place within the azimuth and range limits of the engagement envelope of the generic system. Where intercept is feasible, an intercept time is calculated and battery firing processes are scheduled.

Two fire doctrines are considered, shoot-look-shoot and shoot-shoot look. Currently, Nike Hercules and Patriot utilize shoot-look-shoot doctrines against all targets; HAWK units utilize shoot-shoot-look doctrine until the fire unit engaging the target has less than 2 ready missiles or the battery as a whole has less than 9 missles. HAWK then transitions to the shoot-look-shoot doctrine. Total ammunition status is updated at both the fire unit and battery level after each firing.

Attrition processes are based on a single replication Monte Carlo process, using user specified P_k functions parameterized on range from battery to target for each of the ordnance/system type combinations. Each missile launch is assumed to be independent and one aircraft kill per missile at most is assumed, i.e., no multiple hit/kill per burst phenomena are considered. Instantaneous kill removal occurs in MADEM; i.e., P_k data are assumed to be for K=KILL criteria.

For cases where nuclear warheads are utilized, prompt communications blackout effects are treated. Communications are cut off for

AD-A107 915 BDM CORP MCLEAN VA F/G 15/3
MODULAR AIR DEFENSE EFFECTIVENESS MODEL, PROGRAM DOCUMENTATION --ETC(U)
JAN 80 M FILTEAU, B MACALEER, J T HAWKINS DNA001-79-C-0203
UNCLASSIFIED BDM/W-79-646-TR-VOL-1 DNA-5594F-1 NL

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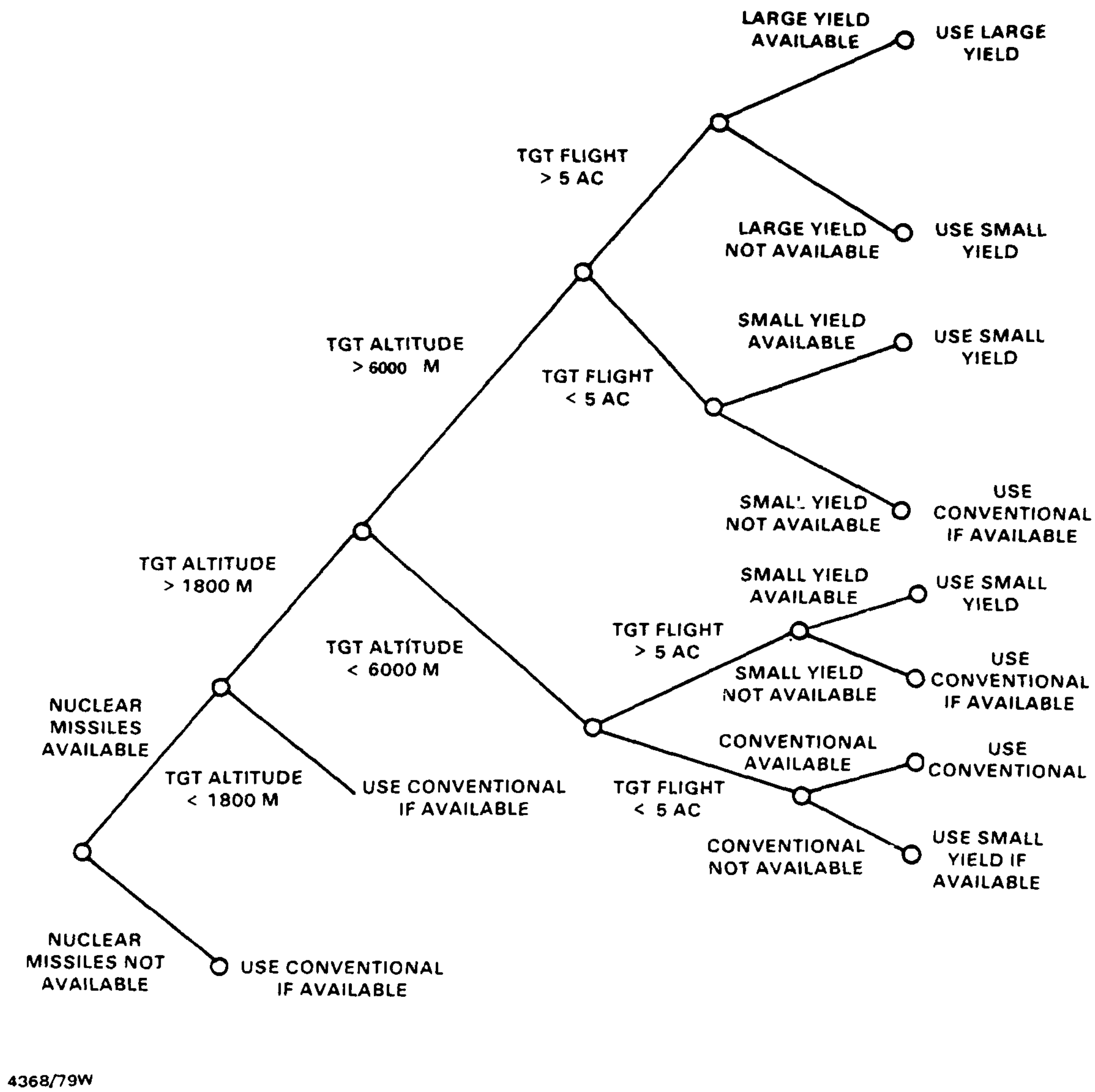

Figure IV-17. NIKE-HERCULES Ordnance Selection

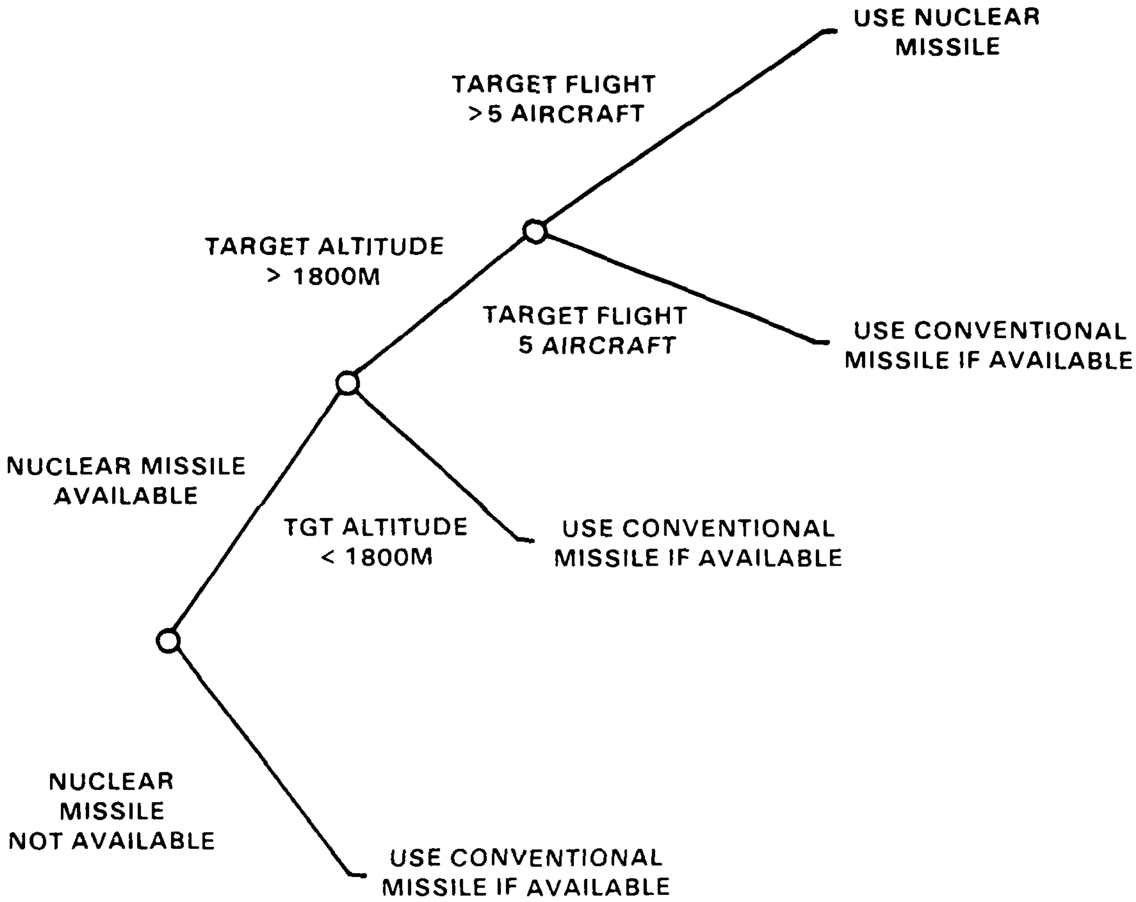

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Figure IV-18. PATRIOT Ordnance Selection Decision Tree

all players located in the same 9.45 km hex as a nuclear burst or in adjacent hexes. For CRC's which are affected, all subordinates (BOC's, interceptors and air bases) go autonomous. For affected BOC's subordinate batteries go autonomous. All interceptors in the affected region go autonomous. Currently no reconstitution capability exists for C^3 processes, i.e., units which go autonomous remain autonomous thereafter. No other degradation of unit effectiveness due to nuclear effects are considered, and no unintentional fasticide of friendly flights is played.

HAWK, Nike Hercules and Patriot units all assess engagement outcomes immediately. The engagement will continue until the battery has expended all of its ammunition, the battery has been killed, the target flight is completely destroyed, or the target flight is out of range. Coverage against the track, however, may be altered to reflect attrition as well as changes in the track priority.

Attrition of flights due to ground based defenses is also exacted by short range air defenses (SHORADS). However, SHORAD players are aggregated in MADEM, rather than being explicitly represented, and attrition processes are coupled to flight movement. As each flight moves across a hex in friendly territory, a P_k for SHORAD systems is determined as a function of the flight's altitude, i.e.,

$$P_k = [.01/\text{Ln (Altitude)}].$$

A single replication Monte Carlo process is then utilized to model a single, independent shot by SHORADS systems against each of the aircraft in the flight. IFF processes are also considered for SHORADS, since friendly aircraft are effectively recognized as friendly 90% of the time. However, hostile aircraft are not identified as friendly. Removal of kills is immediate, and flights may be totally destroyed by SHORADS as for other weapon systems.

c. Air-Surface Processes

Air-surface processes in MADEM consist of execution of attacks by flights of hostile fighter bombers and bombers against all friendly surface players and entities. Surface based, friendly players,

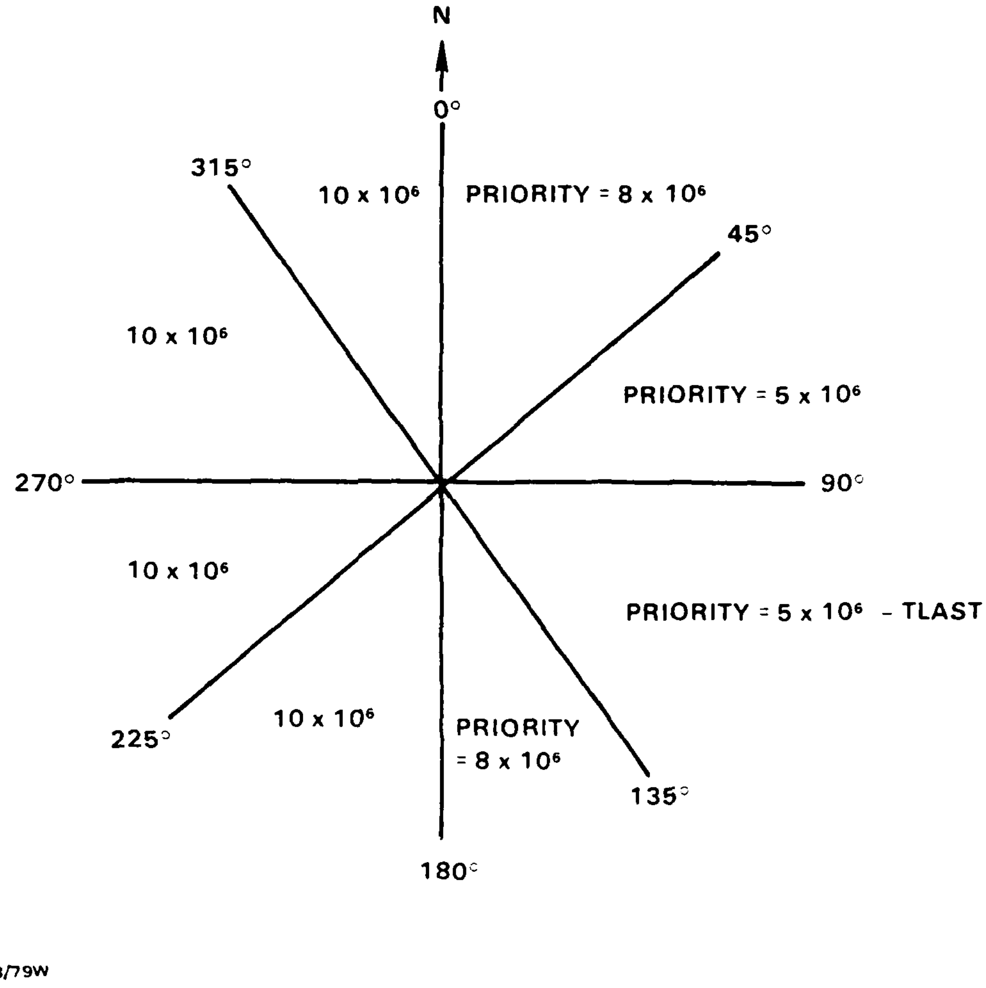


Figure IV-19. Directional Engagement Priorities

including CRC's, BOC's and batteries, are all at risk of being killed by hostile attacks; however, damage from multiple attacks is not accumulated for these players. Damage is accumlated for friendly air bases; however, no degradation of airbase operations due to damage is considered. All other entities in MADEM act as sinks for hostile attacks, with alternative priorities for the Red Planner; damage is accumulated for these targets based on the number of attacks made against them and the ordnance loads of the attacking flights.

As part of the attack planning process, each flight of hostile fighter bombers and bombers is provided with a planned route to its target and the hex location of its target. Flights which successfully reach the target hex attempt to acquire their target. Detection is probabilistic based on a single replication Monte Carlo process for each aircraft in the flight, using input probability of detection values for the target. In the event that the target is not detected, the attack is aborted and the flight returns to its air base. No unassigned surface targets of opportunity are detected or attacked. If the target is successfully detected, an attack is scheduled; no delay times from detection to attack are considered.

The attack process considers attrition due to terminal area short range defenses using the same algorithm as discussed in the section on surface-air processors. Surviving aircraft deliver all of their ordnance on the target; up to 11 alternate types of ordnance can be treated, including 10 alternate conventional types of ordnance and 1 nuclear type of ordnance.

SECTION V

MADEM OPERATION

A. INTRODUCTION

The purpose of this chapter is to explain the operation of MADEM. Additional information on MADEM operations, including job control language files, may be found in Appendices D and E of this manual and in Appendix A of the MADEM Programmer Manual.

MADEM is currently configured for operation on the Air Force Weapons Laboratory (AFWL) computer system. Since many aspects of MADEM operation (including the three processor configuration discussed in the following section) are direct results of AFWL system requirements, the user should pay particular attention to Appendix D before attempting to run MADEM. The user should also be aware that MADEM can be reconfigured to run on other CDC systems with minimal modification.

B. SOFTWARE COMPONENTS

MADEM has three major software components -- a preprocessor, a main processor, and a postprocessor. The overall configuration of these processors and their input and output files is illustrated in Figure V-1.

The preprocessor (sometimes referred to as INITBIN) reads user inputs, which include the data base and Red Threat planning specifications, and carries out the Red Threat planning process. The resulting Red Attack plan is then saved on a "HOLD FILE" for subsequent use by the main processor. In addition to the "HOLD FILES" the preprocessor also outputs a printed summary of the Red Attack plan and a "HISTORY FILE". The HISTORY FILE contains a record of unit creation events which can be used by the postprocessor to construct summary tables of the types of units created.

The main processor (sometimes referred to as RUNBIN) is used to simulate the actual combat processes which result from the Red attack. The main processor is run in a cyclical fashion. The initial main processor

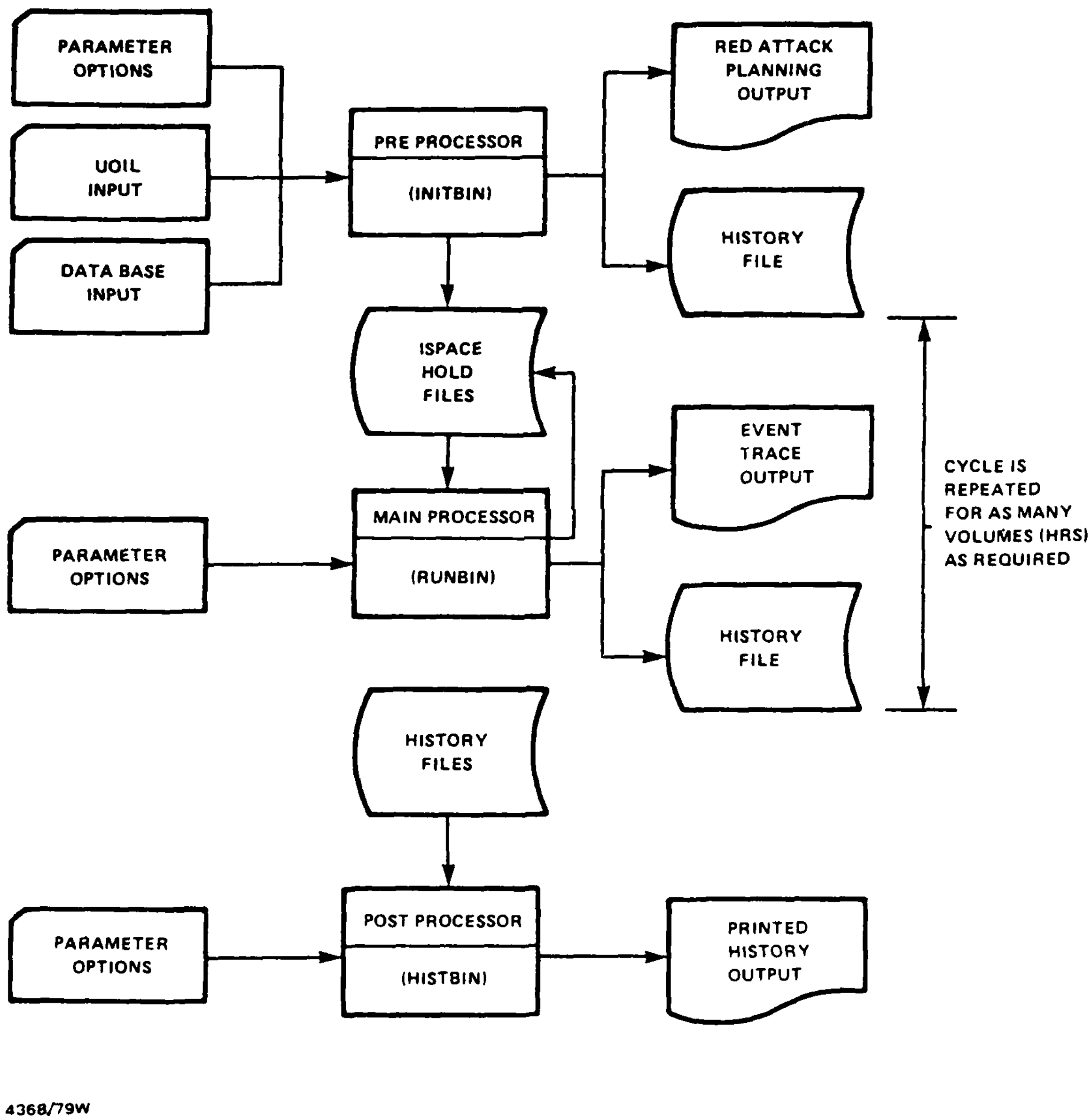


Figure V-1. MADEM Processor Configuration

run is made using the Red Attack Plan HOLD FILE as input. Combat processes are then carried out for approximately one hour of game time after which execution is terminated and HOLD FILES are created containing the status of all units at the end of the hour. This HOLD FILE then becomes the input for the next main processor cycle. Each of these main processor cycles is referred to as a volume. As many volumes can be run as are required to simulate the desired duration of conflict. The main processor also outputs an event trace and a history file. The event trace records all of combat events which occurred during the volume. The HISTORY FILE contains a record of key events which can be used by the postprocessor to summarize the battle.

The postprocessor (sometimes refered to as HISTBIN) reads HISTORY FILES output by the preprocessor and main processor and outputs a variety of tabular summaries of the battle. These outputs include the following:

- Red aircraft acquired by Blue defense units
- Red aircraft engaged by Blue defense units
- Red aircraft damaged by Blue defense units
- Blue units damaged by Red aircraft
- Weapon system expenditures by unit type
- Number of Red aircraft to reach targets
- Number of units created by type.

C. PREPROCESSOR (INITBIN)

MADEM's preprocessor (INITBIN) requires three primary inputs to carry out Red threat planning: a set of Run Parameter Cards, a Data Base File and a User Input Language File. Each of these required inputs is described in detail in the following sections.

1. Run Parameter Cards

The Run Parameter Cards control the preprocessor run. There are two card types. The first is mandatory. The second is optional. The formats of these cards are listed below:

CARD 1: (UNFORMATTED, MANDATORY)

PARM 1 - Must be Integer 1 for INITBIN

PARM 2 - INTEGER, SIZE OF ISPACE (MAX) during INITBIN (50000)

PARM 3 - Max number of players on either side

PARM 4 - Dummy Value (25)

PARM 5 - Dummy value (999999)

PARM 6 - Dummy value (1)

CARD 2 TO THE LAST CARD:

The second set of options are all optional. Each of these parameters must begin in column 1. There may be only 1 Parm Per card, with as many cards as are necessary. It is recommended that these options be used only when debugging.

PARMS:

'DEBUG=ON' - Turns on full debug mode

'DUMP=ON' - Will dump ISPACE at end of run.

'DATFLE=ON' - Turns on display of DATFILE data structure.

'STOP=ODAT' - Stop INITBIN after DATFILE

'STOP=UOIL' - Stops INITBIN after SEMANT (UOIL)

'STOP=DEL' - Stop INITBIN after DELADD, before executing plan event.

'RECOVR=OFF' - Turns off system recovery routine

EXAMPLE:

```
1,500000,600,25, 999999, 1
DEBUG=ON
DUMP=ON
DATFILE=ON
STOP=ODAT
```

2. <u>Data Base File</u> (DATFILE)

The Data Base File contains basic specifications for all of the player units in MADEM as well as probability of kill and probability of detection tables. It consists of a scenario title card and a series of

data class code cards along with their associated specification cards. The number and format of the specification cards will vary with class code.

The first card in the Data Base File must be a Scenario Title Card. This card may contain an up to 70 character description of the scenario to which the data base applies. This description will become the header for the preprocessor printed output.

The Title Card is followed by a series of 13 classes of data. Each class consists of a Class Code Card followed by a series of Specification Cards. The data classes must be inserted in the following order:

	CLASS CODE	DESCRIPTION
(1)	6026	Air Defense Site Data Base
(2)	6006	Unit acquisition range information
(3)	6004	Payload data base
(4)	6003	Aircraft data base
(5)	6005	Flight profiles
(6)	6002	Flight specifications
(7)	6001	Formation specifications
(8)	6007	Air base queue specifications
(9)	6008	Initial assignment of aircraft to air bases.
(10)	6101	Air to air probability of kill
(11)	6102	Air to ground probability of kill
(12)	6103	SAM probability of kill
(13)	6201	Air-to-air probability of death

Each class of data will be shown separately to define the varying input formats for each. Basically, all classes will consist of one class code card followed by specification cards that are unique to each class. The forma. for each card is defined below. On all cards, each field is separated by a comma. Fields which are labeled model value are non-user specified but are required for proper operation of the model.

CLASS 6026

Air Defense Site Data Base

Class Code Card

Field	Title	Description
1	CARDS	Number of items in class
2	CLASS	Class number, must be 6026

Specification Cards

For each item in this class, three cards are required and follow the format of cards A, B, and C described below. Typically, there are six items in this class, each requiring three cards for a total of eighteen specification cards.

Card A Format:

Field	Title	Description
1	TYPE	Unit type number 150 = HAWK BOC 155 = Patriot BOC 160 = Herc BOC 170 = HAWK Battery 175 = Patriot Battery 180 = Herc Battery
2	MODVAL 1	Model value = 1
3	MAXIMUMDIGEST	Maximum number of flights on which unit can be digesting information at any one time. Applies to BOC and BTRY.
4	MAXTIMEDIGEST	Desired interval between digestion of information on a particular track in seconds. Applies to BOC and BTRY.
5	MINTIMEDIGEST	Minimum time between consecutive digests in seconds. Applies to BOC and BTRY.

6	LOSTTIME	Time after which a track not seen is assumed permanently lost in seconds. Applies to BOC and BTRY.
7	LASTCHANCE	Time considered short for a subordinate to respond to a target in seconds (time from now until his last chance to shoot) for BOC. For battery this is Model Value = 0.
8	ENGAGEWINDOW	Minimum length of subordinates engagement window for a significant engagement opportunity in seconds. Applies to BOC and BTRY.
9	MODVAL 2	Model Value = 0
10	MODVAL 3	Model Value = 0.

Card B Format:

Field	Title	Description
1	COVONONE	Desired number of fire units coverage for one aircraft. Applies to BOC and BTRY.
2	ONE	Model Value = 1
3	COVONFEW	Desired number of fire units coverage for few aircraft. Applies to BOC and BTRY.
4	FEW	Model Value = 5
5	COVONMANY	Desired number of fire units coverage for many aircraft. Applies to BOC and BTRY.
6	MANY	Model Value - 1000000
7	TIMEFLIGHT	Maximum time of flight for missile in seconds. Applies to BOC and BTRY.
8	MISSILERANGE	Maximum range for missile in meters. Applies to BOC and BTRY.

Card B Format: (Continued)

Field	Title	Description
9	MAXASSIGN	Maximum number of targets per ready fire unit to be assigned at one time for BOC. For BTRY Model Value = 0
10	MODVAL 4	For BOC, Model Value = 8 For BTRY, Model Value = 11
11	MODVAL 5	Model Value = 0.
12	MAXTRACKRANGE	For BTRY, maximum tracking range in meters for BOC, Model Value = 0.
13	LOCKONTIME	For BTRY, assumed time to achieve lockon in seconds. For BOC, Model Value = 0.

Card C Format:

Field	Title	Description
1	MODVAL 6	Model Value = 0.
2	MODVAL 7	Model value = 0.
3	CONVLOAD	Number of missiles with conventional warheads. - IF HAWK, number of missiles with conventional warheads per fire unit (half the number per battery) -If NIKE HERCULES, number of missiles with conventional warheads per fire unit (per battery) -IF PATRIOT, number of missiles with conventional warheads per battery.
4	SNUKELOAD	Number of missiles with nuclear warheads. - IF HAWK must be 0 - IF NIKE HERCULES, number of missiles with small nuclear warheads - IF PATRIOT number per battery

Card C Format: (Continued)

Field	Title	Description
5	LNUKELOAD	Number of missiles with large nuclear warheads - If HAWK must be 0 - IF NIKE HERCULES, number with large nuclear warheads - IF PATRIOT, must be 0.
6	CVRESUPPLYFREQ	Time between resupply of conventional ammo in seconds for battery. IF BOC, Model Value = 0.
7	RESUPPLYCV	Number of missiles per resupply for conventional ammo for battery. IF BOC, Model Value = 0.
8	SNRESUPPLYFREQ	Time between resupply of small nuke ammo in seconds for battery. - IF BOC, Model Value = 0.
10	LNRESUPPLYFREQ	Time between resupply of large nukes in seconds for battery. If BOC, Model Value = 0.
11	RESUPPLYLN	Number of missiles per resupply for large nukes if battery

EXAMPLE:

```
2, 6026                                                     (Class Code Card)
160, 1, 3, 30, 15, 75., 37., 10., 0., 0.                    (Card A)
1, 1, 2, 5, 3, 1000000, 90., 150000., 1, 8, 5, 5., 5.       (Card B)
0., 0., 0, 0, 0, 0, 0, 0, 0, 0, 0                           (Card C)
180, 1, 3, 30, 15, 75., 0., 10., 0., 0.                     (Card A)
1, 1, 2, 5, 3, 1000000, 90., 150000, 0., 11, 0, 180000.,15. (Card B)
0., 0., 14, 0, 0, 21600, 2, 0, 0, 0, 0                      (Card C)
```

CLASS 6006

Unit Acquisition Range Information

Class Code Card

Field	Title	Description
1	CARDS	Number of items in class
2	CLASS	Class number, must be 6006

Specification Card

For each item in this class, one card is required and follows the format described below. Typically there are four items in this class, each requiring one card for a total of four specification cards.

Field	Title	Description
1	TYPE	Unit type number
2	RANGE	Acquisition range in meters

EXAMPLE:

4, 6006	(Class code card)
220,50000.	(Class description card)
130,200000.	(Class description card)
400, 60000.	(Class description card)
160, 200000.	(Class description card)

CLASS 6004

Payload Data Base

Class Code Card

Field	Title	Description
1	CARDS	Number of payload types in this class
2	CLASS	Class number, must be 6004

Specification Cards

For each item in this class, two cards are required and follow the format of cards A and B described below. There must be an A card for each item and as many B cards as designated in field number 2 of card A.

Card A Format:

Field	Title	Description
1	ICLASS	Payload type identification number Must be 3 for air to ground Must be 4 for air to air
2	INUM	Number of items of this type to follow

Card B Format:

Field	Title	Description
1	INDEX	Identification number, must be unique identifier within this payload type.

EXAMPLE:

2, 6004	(Class code card)
3, 3	(Card A)
1	(Card B)
2	(Card B)
3	(Card B)
4, 1	(Card A)
1	(Card B)

CLASS 6003

Aircraft Data Base

Class Code Card

Field	Title	Description
1	CARDS	Number of items in the class
2	CLASS	Class number - must be 6003

Specification Cards

For each item in this class, two cards are required and follow the format of cards A and B described below. There is one item in this class for each aircraft type.

Card A Format:

Field	Title	Description
1	TYPE	Aircraft type number 401-419 BLUE interceptors 420-439 RED fighters 440-459 RED fighter/bombers 460-479 RED bombers
2	MAXSPEED	Maximum speed in meters/seconds
3	CRUISESPEED	Cruising speed in meters/seconds
4	MAXALTITUDE	Maximum altitude in meters
5	MINALTITUDE	Minimum altitude in meters
6	MAXCLIMBDIVE	Maximum climb/dive rate in meters/ seconds

Card B Format:

Field	Title	Description
1	FUELCONSUME	Fuel consumption rate hex/second
2	ACQRANGE	Acquisition range in meters
3	RADARCS	Radar ARC
4	ATTACKRADIUS	Attack radius in meters
5	MAXFUEL	Maximum fuel load

EXAMPLE:

1, 6003	(Class Code Card)
460, 420, 280., 15000., 100., 1500.	(Card A)
1., 60000., 10., 800000., 200.	(Card B)

CLASS 6005

Flight Profiles

Class Code Card

Field	Title	Description
1	CARDS	Number of items in class
2	CLASS	Class number, must be 6005

Specificaton Cards

For each item in this class, one card is required and follows the format described below. Typically there are four items in this class, each requiring one card for a total of four specification cards.

Field	Title	Description
1	TYPE	Profile identication number
2	ALTCREN	Altitude of first leg in meters
3	ALTOTGT	Altitude of second leg in meters
4	ALTOAB	Altitude of third leg in meters

EXAMPLE:

2, 6005	(Class code card)
1, 10000., 10000., 10000.	(Class description card)
2, 5000., 500., 5000.	(Class description card)

CLASS 6002

Flight Specifications

Class Code Card

Field	Title	Description
1	CARDS	Number of items in this class
2	CLASS	Class number, must be 6002

Specification Cards

For each item in this class, two cards are required and follow the format of cards A and B described below. There must be one A card for each flight type and as many B cards as designated in Field number 9 of card A.

Card A Format:

Field	Title	Description
1	TYPE	Flight specification number
2	IACTYPE	Aircraft type number (400 series) must match a number in class 6003, card A, field 1
3	MAXNOAC	Maximum number of aircraft in flight
4	MINOAC	Minimum number of aircraft in flight
5	MULTAC	Multiples of aircraft required for flight
6	PROFILE	Profile identification number for this flight. Must match an ID number in field one of a class 6005 specification card.
7	SPFLTC	Flight cruising speed in meters/seconds
8	DISTSEP	Flight separation distance in meters
9	NOPAYS	Number of payloads

Card B Format:

Field	Title	Description
1	IPAYTYP	Payload type identification number (3 or 4)
2	MAXAMT	Maximum number of loads of this payload
3	MINAMT	Minimum number of loads of this payload

4	IPAYID	Identification number of particular payload within type. Must match a number in field one of card B, class 6004.

EXAMPLE:

1, 6002	(Class Code Card)
7, 401, 4, 2, 2, 4, 350., 500., 3	(Card A)
4, 2, 2, 1	(Card B)
4, 2, 2, 2	(Card B)
4, 4, 4, 3	(Card B)

CLASS 6001

Formation Specifications

Class Code Card

Field	Title	Description
1	CARDS	Number of items in this class
2	CLASS	Class number, must be 6001

Specification Cards

For each item in this class, at least two cards are required and follow the format of cards A and B described below. There must be one card A for each formation type and as many B cards as designated in field number 3 of card A.

Card A Format:

Field	Title	Description
1	TYPE	Formation type number
2	SPFORMC	Formation cruise speed in meters/ seconds
3	NOFLTS	Number of flights in formation

Card B Format:

Field	Title	Description
1	IDFLITE	Flight specification number must match a number in class 6002, card A, Field 1

EXAMPLE:

```
1, 6001          (Class Code Card)
4, 350., 3            (Card A)
7                     (Card B)
5                     (Card B)
2                     (Card B)
```

CLASS 6007

Air Base Queue Specifications

Class Code Card

This class code is not implemented at this time, all values are MODEL VALUES.

EXAMPLE:

1, 6007	(Class Code Card)
1, .005, 0., .2	(Class description card)

CLASS 6008

Initial Assignment of Aircraft to Air Bases

Class Code Card

Field	Title	Description
1	CARD	Number of items in this class
2	CLASS	Class number, must be 6008

Specification Cards

For each item in this class, two cards are required and follow the format of cards A and B described below. There must be an A card for each item and as many B cards as designated in field number 2 of card A.

Card A Format:

Field	Title	Description
1	IDAB	Air Base number
2	NDACTYPES	Number of aircraft types on air base note: Limit of 1 for Blue air bases (multiple air bases may be collocated)

Card B Format:

Field	Title	Description
1	ACTYPE	Aircraft type number (400 series)
2	NUMACRFT	Number of aircraft
3	FORMTYPE	Formation type number - required for blue air bases, and must match class 6001, card A, field 1. - equals zero for red air bases

EXAMPLE:

```
2, 6008           (Class Code Card)
19, 2                   (Card A)
460, 34, 0              (Card B)
440, 17, 0              (Card B)
15, 1                   (Card A)
401, 11, 4              (Card B)
```

CLASS 6101

Air to Air Probability of Kill

Class Code Card

Field	Title	Description
1	CARDS	Number of cards
2	CLASS	Class number, must be 6101

Specification Cards

For each item in this class, one card is required and follows the format described below. At present there is only one item in this class, each requiring one card for a total of one specification cards.

Field	Title	Description
1-8	.PK	Air to air ordnance probability kill.

EXAMPLE:

1, 6101	(Class Code Card)
.1, .2, .3, .4, .5, .6, .7, .8	(Card A)

CLASS 6102

Air to Ground Probability of Kill

Class Code Card

Field	Title	Description
1	CARDS	Number of cards
2	CLASS	Class number, must be 6102

Specification Cards

For each item in this class, one card is required and follows the format described below. At present there are 26 items, and each card having 11 fields forms a 26 X 11 array.

Field	Title	Description
1-11	PK	Probability of kill tables

EXAMPLE:

```
26, 6102                                              (Class Code Card)
0., 0., .2, .1, .9, .04, .02, .26, .31, .33, .4       (Class description card)
0., 0., 0., 0., .21, .33, .01, .12, .2, .35           (Class description card)
0., 0., 0., 0., .21, .33, .01, .12, .2, .35
     .
     .
     .
0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.
```

CLASS 6103

Surface-to-Air Probability of Kill

Class Code Card

Field	Title	Description
1	CARDS	Must Equal 9
2	CLASS	Class Number, must be 6103

Specification Cards

The equation to derive the probability of kill (PK) for surface to air missiles (SAM) is: PK = A+B(R). The coeffeicients in the equation A and B are used as inputs in the datfile. They are values that are derived from the combination of 3 missile types and 3 ordinance types.

Field	Title	Description
1	SAMPKA	For a missile type and ordinance type
2	SAMPKB	For the same missile type and ordinance type

EXAMPLE:

9, 6103	(Class Code Card)
.447, -.01E-5	A, B for Missile Type 1, Ordnance Type 1
.536, -4.0685E-6	A, B for Missile Type 2, Ordnance Type 1
.310, -1.6636E-6	A, B for Missile Type 3, Ordnance Type 1
.00, 0.0	A, B for Missile Type 1, Ordnance Type 2
.96, -1.004787E-6	A, B for Missile Type 2, Ordnance Type 2
.80, 0.0	A, B for Missile Type 3, Ordnance Type 2
.00,0.0	A, B for Missile Type 1, Ordnance Type 3
.00, 0.0	A, B for Missile Type 2, Ordnance Type 3
.90, 0.0	A, B for Missile Type 3, Ordnance Type 3

CLASS 6201

Air-to-Ground Probability of Death

Class Code Card

Field	Title	Description
1	CARDS	Number of cards
2	CLASS	Class number, must be 6201

Specification Cards

For each item in this class, one card is required and follows the format described below. At present a maximum of ten cards are allowed.

Field	Title	Description
1-8	PD	Air to ground probability of death.

EXAMPLE:

```
10, 6201                                  (Class Code Card)
.68,0, 0., 0., .84, 1., 68, .68           (Class Description Card)
1., .68, 0., 0., 0., 0., .68, 0.          (Class Description Card)
0., 0., .68, 0., .68, 0., 0., 1.          (Class Description Card)
    .
    .
    .
0., 0., 0., 0., 0., 0., 0., 0.            (Class Description Card)
```

3. User Input Language File

The User Oriented Input Language File (UOIL) specifies the scenario to be played. This specification consists of a list of commands (stated in the user oriented input language described below) which indicates the positions of various units, the command/control relationships of the units and the structure of the Red Threat Plan. Allowable commands, along with their proper syntax, are listed below. Each sentence is composed of two types of words: constants and variables. Some constants and variables have optional plurals and abbreviations that are shown below. The variable options are listed below each sentence by words in all capital letters. For a complete example of an input language file see the test case in Chapter V of this manual.

- NUMBER UNITTYPE commands NUMBER UNITTYPE.

Where NUMBER = An integer NUMBER

Where UNITTYPE = HAWKBTRY
HERCBTRY
PATBTRY
HAWKBOC
HERCBOC
PATBOC
CRC
AIRBASE
TAB
AWACS
LANCE
HJ
BRIDGE
DEPOS
PERSHING
POL
SASP

ASP
RESERVES
TRAINS
CLVBTRY
VIIIBTRY
CORPBTRY
CORPCP
DIVCP
SOC
ATAF

Optional Plurals:	HAWKBTRY = HAWKBTRYS
	HERCBTRY = HERCBTRYS
	AIRBASE = AIRBASES
	SASP = SASPS
	ASP = ASPS
	RESERVE = RESERVES
	TRAIN = TRAINS
	CLVBTRY = CLVBTRYS
	VIIIBTRY = VIIIBTRYS
	CORPCP = CORPCPS
	DIVCP = DIVCPS
Optional Abbreviations:	CRC = CRP
	CRC = GP
	CRC = GRDUP
	CRC = MCC
	AIRBASE = AB
	commands = cmds
	commands = c

Example:

99 ATAF commands 1 CRC.

1 CRC cmds 4 HAWKBOC.

3 HAWKBOC cmds 28 HAWKBTRY.

- <u>Hex NUMBER has altitude NUMBER LUNIT</u>.

Where NUMBER = An integer NUMBER

Where LUNIT = FEET
METERS

Optional Abbreviations: altitude = alt
feet = ft
meters = m

Example:

Hex 7752352 has altitude 300 feet.

Hex 7753413 has alt 400 m.

- <u>Buffer zone width is NUMBER km</u>.

Where NUMBER = An integer NUMBER

Example:

Buffer zone width is 40 km.

- <u>Random seed is NUMBER</u>.

Where NUMBER = An integer NUMBER

Example:

Random seed is 16.

- <u>SIDE</u>.

Where SIDE = BLUE
NATO
RED
PACT

Example:

BLUE.
PACT.

- <u>Wave NUMBER start time is NUMBER hours onday NUMBER for NUMBER minutes with NUMBER target types.</u>

Where NUMBER = An integer NUMBER

Optional Abbreviations: hours = hrs
minutes = min
onday = day

Example:

Wave 1 start time is 0630 hrs day 1 for 5 min with 5 target types.

- Target type unittype NUMBER formation NUMBER NUMBER km range limits.

Where UNIT TYPE = HAWKBTRY
HERCBTRY
PATBTRY
HAWKBOC
HERCBOC
PATBOC
CRC
AIRBASE
TAB
AWACS
LANCE
HJ
BRIDGE
DEPOS
PERSHING
POL
SASP
ASP
RESERVES
TRAINS
CLVBTRY
VIIBTRY
CORPBTRY
CORPCP
DIVCP
SOC
ATAF

Where NUMBER = An integer NUMBER

Optional Plurals: HAWKBTRY = HAWKBTRYS
HERCBTRY = HERCBTRYS

AIRBASE = AIRBASES
SASP = SASPS
ASP = ASPS
RESERVE = RESERVES
TRAIN = TRAINS
CLVBTRY = CLVBTRYS
VIIIBTRY = VIIIBTRYS
CORPCP = CORPCPS
DIVCP = DIVCPS
formation = formations

Optional Abbreviations: CRC = CRP
CRC = GP
CRC = GRDUP
CRC = MCC
AIRBASE = AB

Example:

Target type HAWKBTRYS, 1 formation 90, 0 km range limits.

Target type PERSHING, 1 formation 200, 50 km range limits.

- Target NUMBER1 unittype is at NUMBER2 latitude NUMBER2 longitude.

Where NUMBER1 = An interger target ID number
Where NUMBER2 = A real decimal degree
Where UNITTYPE = HAWKBTRY
HERCBTRY
PATBTRY
HAWKBOC
HERCBOC
PATBOC

CRC
AIRBASE
TAB
AWACS
LANCE
HJ
BRIDGE
DEPOS
PERSHING
POL
SASP
ASP
RESERVES
TRAINS
CLVBTRY
VIIIBTRY
CORPBTRY
CORPCP
DIVCP
SOC
ATAF

Optional Plurals:

HAWKBTRY = HAWKBTRYS
HERCBTRY = HERCBTRYS
AIRBASE = AIRBASES
SASP = SASPS
ASP = ASPS
RESERVE = RESERVES
TRAIN = TRAINS
CLVBTRY = CLVBTRY
VIIIBTRY = VIIIBTRYS
CORPCP = CORPCPS

DIVCP = DIVCPS
latitude = latitudes
longitude = longitudes

Optional Abbreviations: CRC = CRP
CRC = GP
CRC = GROUP
CRC = MCC
AIRBASE = AB
latitude = lat
longitude = long

Example:

Target, 23 SASP is at 50.0 lat, 8.4 long.
Target, 27 TRAIN is at 48.9 lat, 10.8 long.

- Target NUMBER UNITTYPE is at hex NUMBER.

Where NUMBER = An integer NUMBER

Where UNITTYPE = HAWKBTRY
HERCBTRY
PATBTRY
HAWKBOC
HERCBOC
PATBOC
CRC
AIRBASE
TAB
AWACS
LANCE
HJ

BRIDGE
DEPOS
PERSHING
POL
SASP
ASP
RESERVES
TRAINS
CLVBTRY
VIIIBTRY
CORPBTRY
CORPCP
DIVCP
SOC
ATAF

Optional Plurals:	HAWKBTRY = HAWKBTRYS
	HERCBTRY = HERCBTRYS
	AIRBASE = AIRBASES
	SASP = SASPS
	ASP = ASPS
	RESERVE = RESERVES
	TRAIN = TRAINS
	CLVBTRY = CLVBTRYS
	VIIIBTRY = VIIIBTRYS
	CORPCP = CORPCPS
Optional Abbreviations:	CRC = CRP
	CRC = GP
	CRC = GROUP
	CRC = MCC
	AIRBASE = AB

Example:

Target 13 ATAF is at HEX 7752352.

- <u>Raid NUMBER has NUMBER wave thru NUMBER corridor</u>.

Where NUMBER = A real NUMBER

Optional Plurals: raid = raids
wave = waves
corridor = corridors

Example:

Raid 23 has 3 wave thru 2 corridor.

- <u>Raid NUMBER</u>.

Where NUMBER = An integer NUMBER

Optional Plurals: raid = raids

Example:

Raid 4.

- <u>Red theater operations</u>.

Optional Plurals: theater = theaters

Example:

Red theater operations.

- <u>NUMBER UNITTYPE is at NUMBER NUMBER NUMBER latitude NUMBER NUMBER NUMBER longitude</u>.

Where NUMBER = A Real	NUMBER (Decimal Degrees)
Where UNITTYPE =	HAWKBTRY
	HERCBTRY
	PATBTRY
	HAWKBOC
	HERCBOC
	PATBOC
	CRC
	AIRBASE
	TAB
	AWACS
	LANCE
	HJ
	BRIDGE
	DEPOS
	PERSHING
	POL
	SASP
	ASP
	RESERVES
	TRAINS
	CLVBTRY
	VIIIBTRY
	CORPBTRY
	CORPCP
	DIVCP
	SOC
	ATAF

Optional Plurals: HAWKBTRY = HAWKBTRYS
HERCBTRY = HERCBTRYS
AIRBASE = AIRBASES
SASP = SASPS
ASP = ASPS
RESERVE = RESERVES
TRAIN = TRAINS
CLVBTRY = CLVBTRYS
VIIIBTRY = VIIIBTRYS
CORPCP = CORPCPS
DIVCP = DIVCPS
latitude = latitudes
longitudes = longitudes

Optional Abbreviations: CRC = CRP
CRC = GP
CRC = GRDUP
CRC = MCC
AIRBASE = AB
latitude = lat
longitude = long

Example:

4 HAWKBOC is at 49.0 lat 11.9 long.
15 AIRBASE is at 50.2 lat 8.0 long.
14 HERCBTRY is at 48.3 lat 11.4 long.

- Label.

Example:

Label.
MADEM TEST RUN
Label.
FINAL TEST RUN

- <u>Game starts at NUMBER hours on day NUMBER</u>.

  Where NUMBER = An integer NUMBER

  Optional Abbreviations: HOURS = HRS

  Example:

  Game starts at 1100 hours on day 1.

- <u>Corridor NUMBER limits are NUMBER latitude NUMBER longitude NUMBER latitude NUMBER longitude</u>.

  Where NUMBER = A real NUMBER (Decimal Degress)

  Optional Plurals: latitude = latitudes
  longitude = longitudes

  Optional Abbreviations: latitude = lat
  longitude = long

  Example:

  Corridor 1 limits are 50.25 lat, 12.0 long, 50.33 lat, 11.64 long.

- <u>Corridor NUMBER limits are NUMBER NUMBER NUMBER latitude NUMBER NUMBER NUMBER longitude</u>.

  Where NUMBER = An integer NUMBER

  Optional Plurals: latitude = latitudes
  longitude = longitudes

  Optional Abbreviations: latitude = lat
  longitude = long

Example:

Corridor 4 limits are 48.6 latitude 10.3 longitude.

- <u>Corridor NUMBER depth is NUMBER km heading NUMBER degree spread angle NUMBER degree</u>.

Where NUMBER = An integer NUMBER

Optional Plurals: degree = degrees

Optional Abbreviations: degree = deg

Example:

Corridor 1 depth is 70 km. heading 245 deg. spread angle 60 deg.

- <u>NUMBER type NUMBER formation</u>.

Where NUMBER = An integer NUMBER

Optional Plurals: formation = formations

Example:

6 type 3 formations.

- <u>NUMBER UNITTYPE is at hex NUMBER</u>.

Where NUMBER = An integer NUMBER

Where UNITTYPE = HAWKBTRY
HERCBTRY
PATBTRY
HAWKBOC

HERCBOC
PATBOC
CRC
AIRBASE
TAB
AWACS
LANCE
HJ
BRIDGE
DEPOS
PERSHING
POL
SASP
ASP
RESERVES
TRAINS
CLVBTRY
VIIIBTRY
CORPBTRY
CORPCP
DIVCP
SOC
ATAF

Optional Plurals:

HAWKBTRY = HAWKBTRYS
HERCBTRY = HERCBTRYS
AIRBASE = AIRBASES
SASP = SASPS
ASP = ASPS
RESERVE = RESERVES
TRAIN = TRAINS
CLVBTRY = CLVBTYS

VIIIBTRY = VIIIBTRYS

CORPCP = CORPCPS

DIVCP = DIVCPS

Optional Abbreviations: CRC = CRP

CRC = GP

CRC = GRDUP

CRC = MCC

AIRBASE = AB

Example:

10 HAWKBTRY is at HEX 774225.

12 PATBTRY is at HEX 7777526.

D. MAIN PROCESSOR (RUNBIN)

MADEM's main processor (RUNBIN) requires two primary inputs: a set of Run Parameter Cards and a set of two Hold Files. Each of these required inputs is described below.

1. Run Parameter Cards

The Run Parameter Cards control the main processor run. There are two card types. The first is mandatory. The second is optional. The formats of these cards are listed below:

CARD 1:

PARM 1 - Must be integer '2' for RUNBIN

PARM 2 - Integer, max size of ISPACE. (100000)

PARM 3 - Integer, max number of payers on either side.

PARM 4 - Real, max CPU time of volume (in seconds)

PARM 5 - Real, max game time of this volume.

PARM 6 - Integer, max number of events for this volume.

CARD 2 TO THE LAST CARD:

The second set of options are all optional. Each of these PARMS must begin in column 11. There may be only 1 Parm Per card, with as many cards as are necessary. It is recommended that these options be used only when debugging PARMS:

'DEBUG=ON' - Turns on full debug mode

'DUMP=ON' - Will dump ISPACE at end of volume.

'RECOR=OFF' - Turn off system recovery routine

EXAMPLE:

2,100000,600,250,999999,20000
DEBUG=ON
DUMP=ON

2. Hold Files

The two Hold Files that are used as input to the MADEM main processor are created by the preprocessor. These files need not concern the user because they are automatically saved and accessed by the current Job Control Language (JCL). This will allow the entire data base to be saved for restarts of the main processor.

E. POSTPROCESSOR (HISTBIN)

MADEM's postprocessor (HISTBIN) provides printed summaries of a variety of MADEM events. It requires two inputs: a set of Run Parameter Cards and History Files. Each of these required inputs is described below.

1. Run Parameter Cards

The Run Parameter Cards control the main processor run. There are two card types. The formats of these cards are listed below:

CARD 1:

Up to 70 character description of the scenario.

CARD 2:

Up to 5 points in model time for which summary statistics are required. If the first time is negative the special option to list attacks-on-acquisition is engaged.

EXAMPLE:

```
CONVENTIONAL        1978      AAA       LEVEL     2 PK
390001, 999999999., 999999999., 999999999., 999999999.
```

Note that the last four parameters on card 2 of the example are essentially dummy parameters. Since there are no events after time 390001, only one history "snapshot" will be taken.

2. History Files

The history files that are used as input to the MADEM postprocessor are created by the preprocessor and the main processor. These files need not concern the user because they are automatically saved and accessed by the current job control cards (JCL). These files contain event information to be extracted and organized in a meaningful format to analyze the model run.

SECTION VI
EXAMPLE CASE

A. INTRODUCTION

The purpose of this chapter is to describe all of the required inputs and resulting outputs associated with a simple MADEM scenario. The scenario used in this example case is a variant of the basic test data set which was used to develop and debug the current version of MADEM. Section B describes the basic elements of the scenario while sections C and D describe the required inputs and resulting outputs.

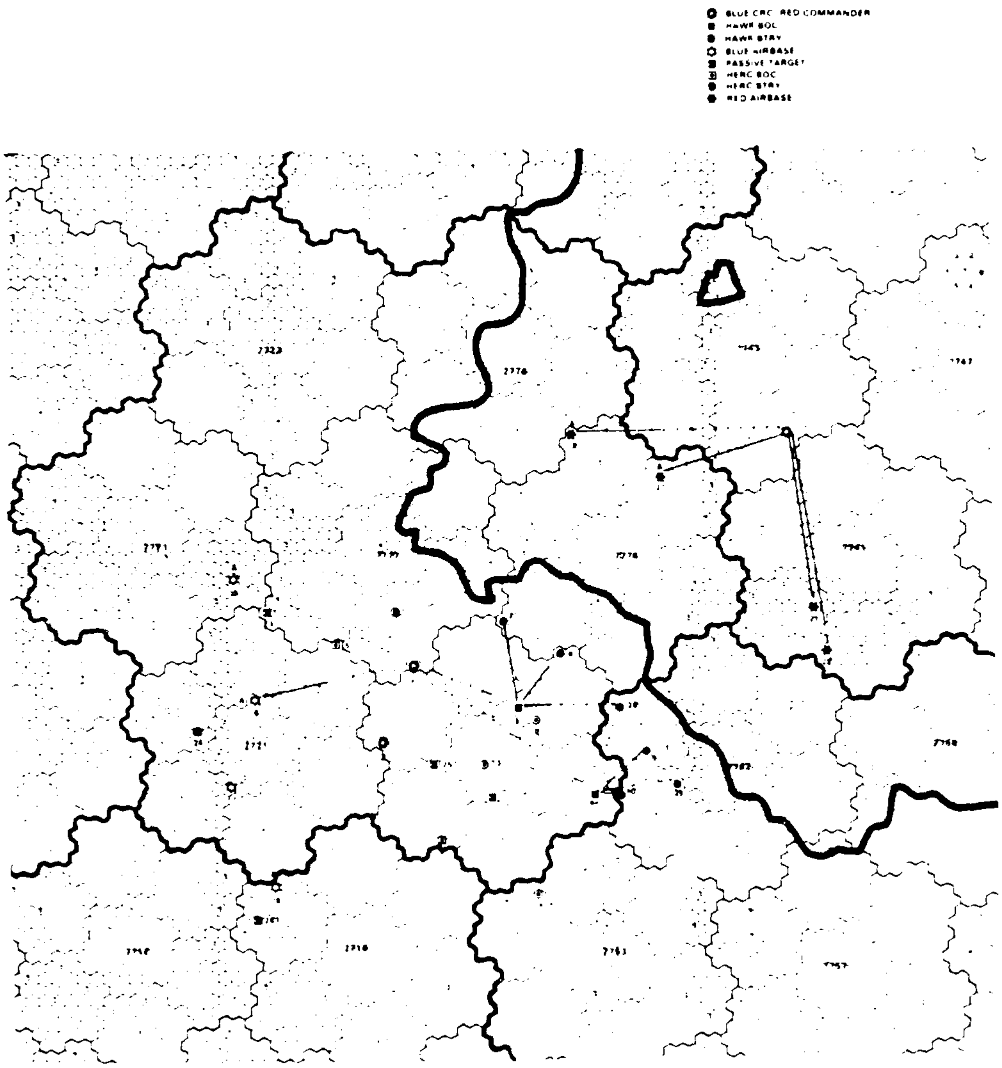
B. SCENARIO SPECIFICATION

1. General Description

The scenario used in this example represents a considerable simplification of typical MADEM analysis run. While the overall configuration of units is realistic, the total unit density in the simulated battle area is much lower than the actual unit density in the 2 and 4 ATAF area represented in the scenario. This lower unit density was used to simplify the scenario for explanatory purposes and to reduce the run time and storage requirements for testing.

2. Unit Locations and C^2 Relationships

Figure VI-1 shows the locations of all units in the scenario and their command/control relationships. Figure VI-2 shows the LAT/LONG overlay used to input unit locations in the user input language file. The Red theater commander, located to the right of the border line, commands four Red airbases. Each of the two combat reporting centers on the blue side commands two airbases, and two battalion operations centers. Each HAWK BOC in turn commands three HAWK batteries, while each Nike-Hercules BOC commands two Nike-Hercules batteries. In addition, a number of passive targets have been included on the Blue side to draw additional red attacks. It should be noted that these passive targets are not connected to the C^2 tree and do not play an active role in the battle.



4368/79W

Figure VI-1. Locations and C^2 Relationships

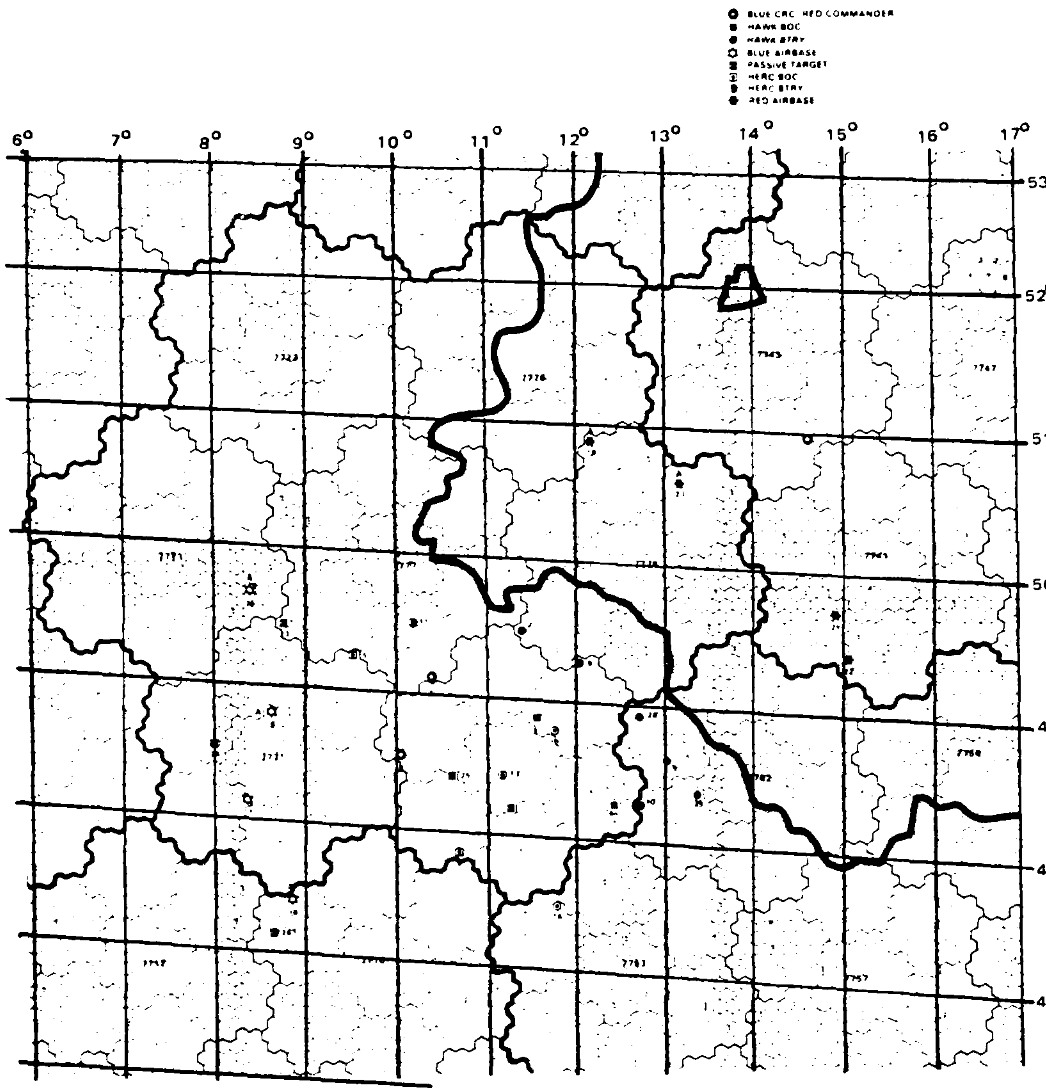


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Figure VI-2. Latitude and Longitude Overlay

3. Blue Air Defense Specification

The Blue side's defensive assets include the aircraft on the four blue airbases and the ten SAM batteries. Each of the Blue airbases has been assigned 12 interceptor aircraft. These interceptors must fly in flights of 2 to 4 aircraft. Each HAWK battery has been supplied with 18 conventional missiles. Nike-Hercules batteries have been supplied with 14 conventional missiles each. All blue SAM batteries will be resuppiied with 2 missiles every 6 hours. Missile fire ranges for all batteries are indicated in Figure VI-3. Further details of the Blue defenses can be found in the sample data base file in figure VI-6 in section C.1 of this chapter.

4. Red Attack Specification

The aircraft on the red airbases constitute the Red side's primary offensive assets. Assignments of aircraft to the four red airbases are as follows:

AIRBASE	BOMBERS	FIGHTER/BOMBERS	FIGHTERS
19	34	15	11
20	32	24	9
21	32	23	17
22	36	24	16

In contrast to the simple flight assignment used on the Blue side, a more complex assignment of aircraft to flight and formation types has been used on the Red side. Specified flight assignments for the Red side include the following:

FLIGHT TYPE	NUMBER OF AIRCRAFT
6	2 - 4 FIGHTERS
5	2 - 6 FIGHTERS
4	2 - 4 FIGHTER/BOMBERS
3	3 - 6 FIGHTER/BOMBERS
2	8 - 12 BOMBERS
1	4 - 16 BOMBERS

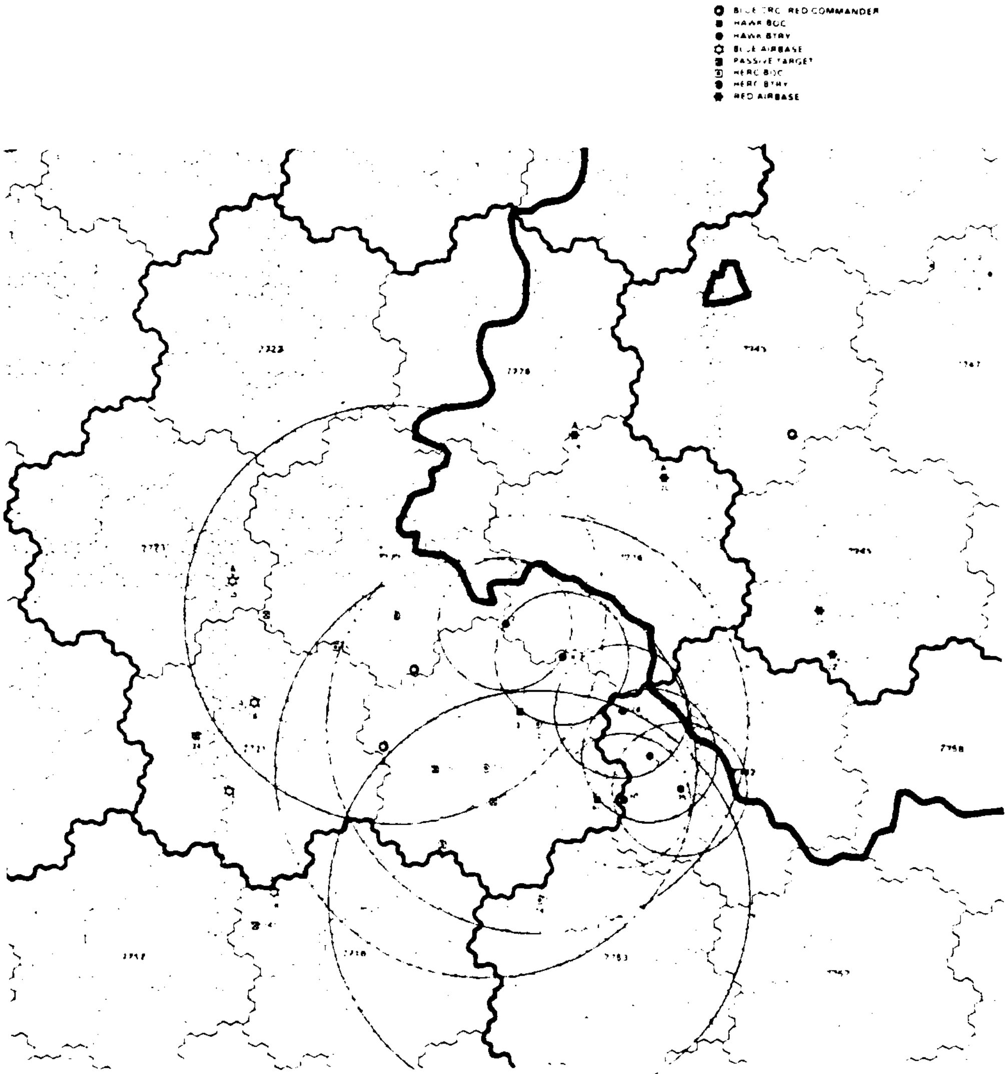

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Figure VI-3. Missle Ranges

It should be noted that each of the above flight types carries a different user defined weapons package.

These Red flights must be further grouped into formation types for assignment to Blue targets. Specified formation types are as follows:

FORMATION TYPE	FLIGHT TYPES IN THE FORMATION
3	2 - 4 FIGHTER/BOMBERS - Type 4
2	3 - 6 FIGHTER/BOMBERS - Type 3
	2 - 6 FIGHTERS - Type 5
	8 - 12 BOMBERS - Type 2
1	4 - 16 BOMBERS - Type 1
	2 - 4 FIGHTERS - Type 6

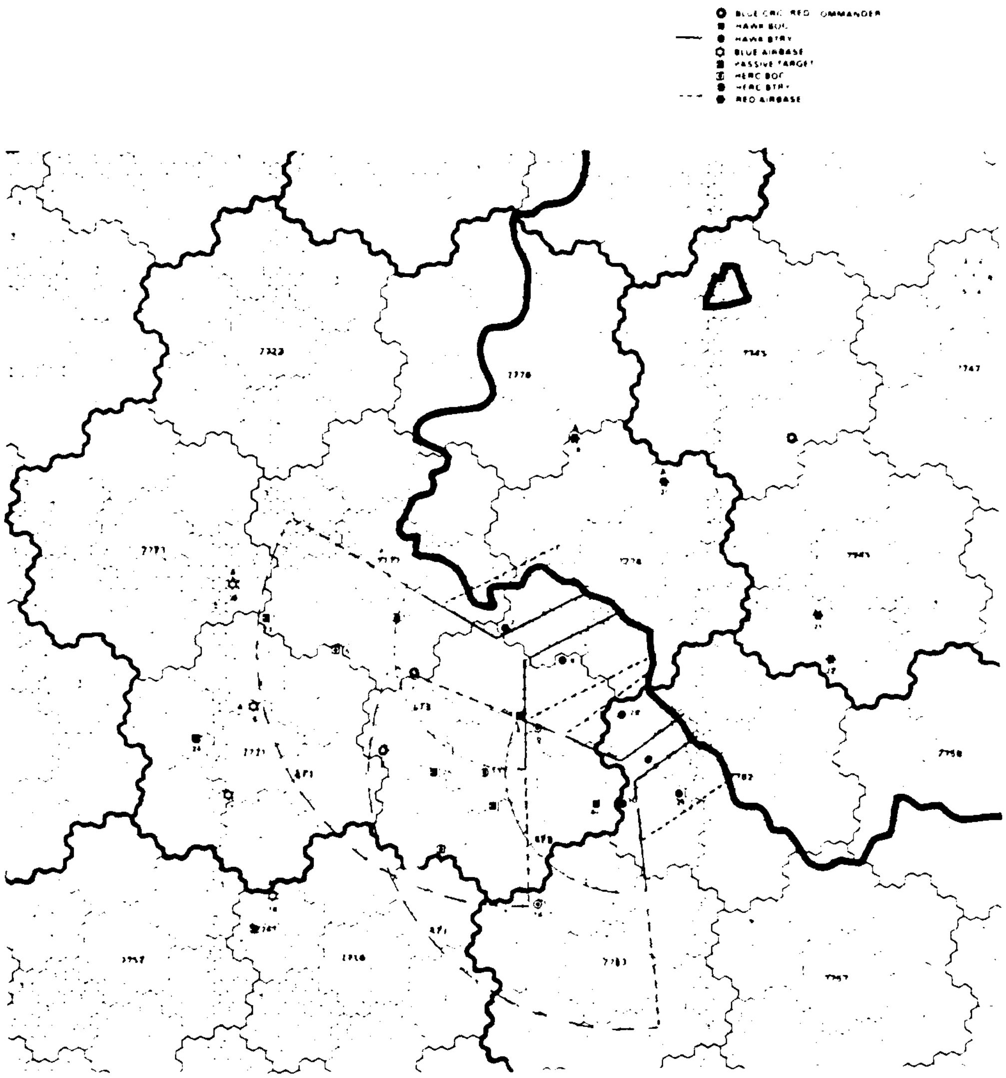
In this scenario these formation types have been used to specify a two wave raid on the Blue side. The specification parameters for each wave in the raid are discussed below. The Red attack plans, which the model generates from these specifications, are discussed in section D.1 of this chapter.

a. First Wave - Corridor Clearing

The first wave attack specifications for this scenario are illustrated in Figure VI-4. The purpose of this wave is to clear the attack corridors of SAM batteries. The specifications for this wave are input in the user input language file listed in section C.1 of this chapter. They specify two attack corridors with 40 km buffer zones. Up to 6 type 3 formations may be assigned by the red theater planner to attack HAWK batteries within 90 km of the corridor exits. Up to 2 type 1 formations may be assigned by the red theater planner to attack Nike-Hercules batteries within 190 km of the corridor exits. It should be noted that these are the maximum allocations input by the user. They act as constraints upon the actions of the model which may assign fewer formations than specified due to lack of aircraft.

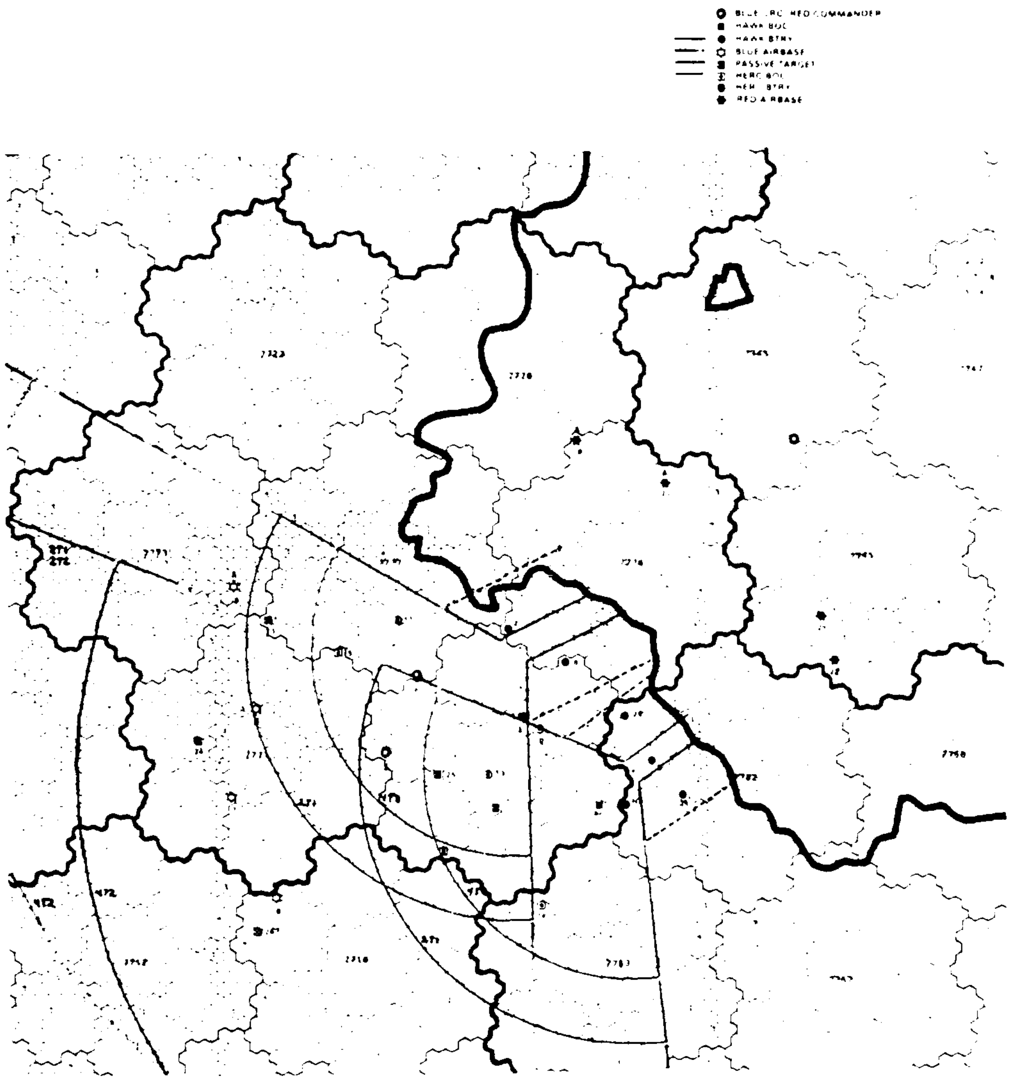
b. Second Wave - Deep Penetration

Figure VI-5 illustrates the second wave attack specifications for this scenario. The same two corridors have been specified for



4368/79W

Figure VI-4. First Wave Attack Specifications



4368/79W

Figure VI-5. Second Wave Attack Specifications

use in this wave as in the first wave. Corridors should have been cleared of SAM batteries in the first wave. The primary purpose of this wave is to penetrate deep into Blue air-space to attack airbases and passive targets. If further corridor clearing is required up to 4 type 3 formations may be assigned to attack HAWK batteries within 150 km of the corridor exit. Airbases may be attacked with up to 4 type 2 formations. The two types of passive targets (SASPS and HJ's) may be attacked with up to 2 type 1 plus 2 type 2 and 2 type 1 formations respectively.

C. REQUIRED INPUTS

A MADEM simulation is run in three stages: the preprocessor, the main processor, and the post processor. The main processor can run in several volumes, generally between six and twelve volumes. MADEM runs at the AFWL computer center on either of the two CDC Cyber 176 computers (MFY or MFX). MADEM cannot run the Cyber 166, referred to as MFB.

This section includes all the required inputs to run an example MADEM simulation, including Job Control Language (JCL) to run all three stages of MADEM as well as the Data Base File and User Oriented Input Language File (UOIL) necessary to run the preprocessor. In the sample JCL streams, the second card, the account card, will have to be altered to provide a valid account number and password. See Appendix D for explanations of the first two JCL cards and the end-of-record and end-of-information cards.

1. Preprocessor Input

To run the preprocessor for our example case the following permanent files must reside on the AFWL system:

MADEMINITBIN	-	Executable preprocessor program
DATFILEEXAMPLE	-	Example data base.
UOILEXAMPLE	-	Example User Input Language File.

See figures VI-6 and VI-7 respectively, for the sample Data Base File and the sample User Oriented Input Language File.

```
DATFILE TEST CASE 1 -- CONVENTIONAL 4 DEC 1979
6026
180,1,3,30,15,75.,0.,10.,0.,0.
1,1,2,5,3,1000000,90.,150000.,9,11,0.,180000.,15.
0.,0.,14,0,0,21600,2,0,0,0,0
175,1,12,30,15,75.,0.,10.,0.,0.
1,1,2,5,3,1000000,60.,90000.,0,11,0.,100000.,15.
0.,0.,20,0,0,21600,2,0,0,0,0
170,1,3,30,15,75.,0.,10.,0.,0.
1,1,2,5,3,1000000,45.,50000.,0,11,0.,100000.,15.
0.,0.,18,0,0,21600,2,0,0,0,0
160,1,3,30,15,75.,37.,10.,0.,0.
1,1,2,5,3,100000,90.,150000.,1,8,5.,5.,5.
0.,0.,0,0,0,0,0,0,0,0,0
155,1,15,30,15,75.,37.,30.,0.,0.
1,1,2,5,3,1000000,60.,90000.,1,8,5.,5.,5.
0.,0.,0,0,0,0,0,0,0,0,0
150,1,3,30,15,75.,37.,10.,0.,0.
1,1,2,5,3,1000000,45.,50000.,1,8,5.,5.,5.
0.,0.,0,0,0,0,0,0,0,0,0
7,6006
220,50000.
130,200000.
400,60000.
160,200000.
150,200000.
130,300000.
170,100000.
2,6004
3,6
1
2
3
4
5
6
4,3
1
2
3
4,6003
460,420,280.,15000.,100.,1500.
1.,60000.,10.,800000.,200.
440,435.,290.,17000.,50.,1500.
1.,60000.,4.,800000.,200.
420,480.,320.,20000.,50.,1500.
1.,60000.,2.,800000.,200.
```

Figure VI-6. Sample Data Base File

```
401,525.,350.,20000.,150.,1500.
1.,60000.,3.,800000.,200.
4,6005
4,10000.,10000.,10000.
8,5000.,5000.,5000.
2,500.,500.,5000.
1,5000.,500.,5000.
7,6002
7,401,4,2,2,4,350,500.,3
  2,2,1
4,2,2,2
4,4,4,3
6,420,4,2,1,3,320.,500.,2
4,3,3,1
4,4,4,2
5,420,6,2,1,2,320.,500.,2
4,4,4,1
4,2,2,2
4,440,4,2,1,1,290.,500.,3
4,2,2,2
3,4,4,4
3,4,4,6
3,440,6,3,1,2,290.,500.,3
4,3,3,1
3,8,8,4
3,2,2,6
2,460,12,8,2,3,280.,500.,1
3,6,6,5
1,460,16,4,2,3,280.,500.,2
3,4,4,5
3,2,2,6
4,6001
4,350.,1
7
  290.,1
4
2,280.,3
3
5
2
1,280.,2
1
6
1,6007
1,.005,0.,.2
8,6008
19,3
460,34,0
440,15,0
```

Figure VI-6. Sample Data Base File (Continued)

```
420,11,0
20,3
460,32,0
440,24,0
420,9,0
21,3
460,32,0
440,23,0
420,17,0
22,3
 60,36,0
440,24,0
420,16,0
15,1
401,12,4
16,1
401,12,4
 7,1
401,12,4
18,1
401,12,4
1,6101
.25,.24,.26,.25,.02,.26,.25,.02,.0,.0
26,6102
.0   ,.0   ,.0   ,.0   ,.0013,.0   ,.0403,.1624,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.0013,.0   ,.0403,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.3687,.9567,.0   ,.0988,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.3014,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.3014,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0287,.0316,.0   ,.0322,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0305,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0646,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.1456,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.5236,.0   ,.3638,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.0626,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.2435,.0800,.0   ,.0   ,.0   ,.1663,.2493,.0   ,.0   ,.0   ,.0
.4986,.0   ,.0   ,.0   ,.0   ,.0   ,.2500,.0   ,.0   ,.0   ,.0
.4950,.2240,.0   ,.0   ,.0   ,.0   ,.2430,.0   ,.0   ,.0   ,.0
.0   ,.0020,.0   ,.0044,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.1840,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.1840,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.1840,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.7664,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.1840,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.2250,.0   ,.5030,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0700,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0158,.0   ,.0593,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0306,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0   ,.0
```

Figure VI-6. Sample Data Base File (Continued)

```
9,6103
.447, -1.01E-5
.536, -4.0685E-6
.310, -1.6636E-6
 .00,  0.0
 .96, -1.004787E-6
 .80,  0.0
 .00,  0.0
 .00,  0.0
 .90,  0.0
10,6201
.68,0.,0.,0.,.84,1.,.68,.68
1.,.68,0.,0.,0.,0.,.67,0.
0.,0.,.68,0.,.68,0.,0.,1.
.68,0.,0.,1.,0.,0.,.68,0.
0.,0.,0.,0.,0.,0.,.84,0.
0.,0.,1.,1.,.68,0.,1.,1.
0.,.67,0.,0.,0.,0.,.68,0.
0.,0.,0.,.84,1.,0.,.68,0.
0.,0.,0.,0.,0.,0.,0.,0.
0.,0.,0.,0.,0.,0.,0.,0.
```

Figure VI-6. Sample Data Base File (Continued)

```
LABEL.
MADEM TEST RUN            5 MAY 1977
LABEL.
FINAL TEST RUN WITH INPUT AND PLAN
BLUE.
99 ATAF COMMANDS 1 CRC.
1 CRC IS AT 49.7 LAT 10.0 LONG.
99 ATAF COMMANDS 2 CRC.
2 CRC IS AT 49.2 LAT 9.7 LONG.
1 CRC COMMANDS 3 HAWKBOC.
3 HAWKBOC IS AT 49.5 LAT 11.1 LONG.
1 CRC COMMANDS 4 HAWKBOC.
4 HAWKBOC IS AT 49.0 LAT 11.9 LONG.
2 CRC COMMANDS 5 HERCBOC.
5 HERCBOC IS AT 49.8 LAT 9.1 LONG.
2 CRC COMMANDS 6 HERCBOC.
6 HERCBOC IS AT 48.6 LAT 10.3 LONG.
3 HAWKBOC COMMANDS 7 HAWKBTRY.
7 HAWKBTRY IS AT 50.1 LAT 10.8 LONG.
3 HAWKBOC COMMANDS 8 HAWKBTRY.
8 HAWKBTRY IS AT 49.9 LAT 11.5 LONG.
3 HAWKBOC COMMANDS 28 HAWKBTRY.
28 HAWKBTRY IS AT 49.58 LAT 12.02 LONG.
4 HAWKBOC COMMANDS 9 HAWKBTRY.
9 HAWKBTRY IS AT 49.3 LAT 12.3 LONG.
  HAWKBOC COMMANDS 10 HAWKBTRY.
10 HAWKBTRY IS AT 49.0 LAT 12.1 LONG.
4 HAWKBOC COMMANDS 29 HAWKBTRY.
29 HAWKBTRY IS AT 49.1 LAT 12.7 LONG.
5 HERCBOC COMMANDS 11 HERCBTRY.
11 HERCBTRY IS AT 50.1 LAT 9.7 LONG.
5 HERCBOC COMMANDS 12 HERCBTRY.
12 HERCBTRY IS AT 49.4 LAT 11.2 LONG.
6 HERCBOC COMMANDS 13 HERCBTRY.
13 HERCBTRY IS AT 49.1 LAT 10.8 LONG.
6 HERCBOC COMMANDS 14 HERCBTRY.
14 HERCBTRY IS AT 48.3 LAT 11.4 LONG.
1 CRC COMMANDS 15 AIRBASE.
15 AIRBASE IS AT 50.2 LAT 8.0 LONG.
1 CRC COMMANDS 16 AIRBASE.
16 AIRBASE IS AT 49.4 LAT 8.4 LONG.
2 CRC COMMANDS 17 AIRBASE.
17 AIRBASE IS AT 48.8 LAT 8.2 LONG.
2 CRC COMMANDS 18 AIRBASE.
18 AIRBASE IS AT 48.2 LAT 8.8 LONG.
TARGET,   23 SASP IS AT 50.0 LAT, 8.4 LONG.
TARGET,   24 SASP IS AT 49.2 LAT, 7.8 LONG.
TARGET,   25 SASP IS AT 49.1 LAT, 10.2 LONG.
```

Figure VI-7. User Oriented Input Language File

```
TARGET,   26 SASP IS AT 48.0 LAT, 8.6 LONG.
TARGET,   27 HJ   IS AT 48.9 LAT, 10.8 LONG.
RED.
30 WP COMMANDS 19 AIRBASE.
30 WP IS AT 51.5 LAT, 13.8 LONG.
19 AIRBASE IS AT 51.4 LAT, 11.4 LONG.
30 WP COMMANDS 20 AIRBASE.
20 AIRBASE IS AT 51.1 LAT, 12.4 LONG.
30 WP COMMANDS 21 AIRBASE.
21 AIRBASE IS AT 50.35 LAT 14.08 LONG.
30 WP COMMANDS 22 AIRBASE.
22 AIRBASE IS AT 50.1 LAT, 14.2 LONG.
RED THEATER OPERATIONS.
RAID 1   .
CORRIDOR 1 LIMITS ARE 50.25 LAT, 12.0 LONG, 50.33 LAT, 11.64 LONG.
CORRIDOR 1 DEPTH IS 70 KM, HEADING 245 DEG, SPREAD ANGLE 60 DEG.
BUFFER ZONE WIDTH IS 40 KM.
CORRIDOR 2 LIMITS ARE 49.5 LAT, 12.9 LONG, 49.63 LAT, 12.72 LONG.
CORRIDOR 2 DEPTH IS 60 KM, HEADING 230 DEG, SPREAD ANGLE 60 DEG.
BUFFER ZONE WIDTH IS 40 KM.
WAVE 1 START TIME IS 0630 HRS DAY 1 FOR 5 MIN.
TARGET TYPE HAWKBTRYS, 1 FORMATION 90,0 KM RANGE LIMITS.
6 TYPE 3 FORMATIONS.
TARGET TYPE HERCBTRYS, 1 FORMATION, 190,20 KM RANGE LIMITS.
2 TYPE 1 FORMATIONS.
WAVE 2 START TIME IS 0645 HRS DAY 1 FOR 10 MIN.
TARGET TYPE HAWKBTRYS, 1 FORMATION, 150,0 KM RANGE LIMITS.
  TYPE 3 FORMATIONS.
TARGET TYPE AIRBASES, 1 FORMATION,400,150 KM RANGE LIMITS.
4 TYPE 2 FORMATIONS.
TARGET TYPE SASPS, 2 FORMATIONS, 440, 60 KM RANGE LIMITS.
2 TYPE 1 FORMATIONS.
2 TYPE 2 FORMATIONS.
TARGET TYPE HJ, 1 FORMATION, 200,50 KM RANGE LIMITS.
2 TYPE 1 FORMATIONS.
```

Figure VI-7. User Oriented Input Language File (Continued)

a. Preprocessor Job Control Language

The preprocessor job control stream in figure VI-8 will execute the MADEM example preprocessor. The COMMENT cards are for your information only, and may be omitted. The three REQUEST cards allocate permanent file space for the History File (TAPE4) and the two Hold Files. The ATTACH cards access the necessary permanent files listed above. After executing INITBIN, the History File and the two Hold Files are saved as permanent files, and the planner output in TAPE14 is sent to the printer. Everything after the EXIT card is only executed if the system abnormally aborts the job stream. In this case debug information will be sent to the printer.

b. Preprocessor Run Parameters

The next to last card in the job stream is the Run Parameters card. In includes six parameters:

(1) a one for INITBIN.

(2) size of ispace (50,000)

(3) maximum number of players on either side (600)

(4) dummy value (25)

(5) dummy value (999999)

(6) dummy value (1)

2. Main Processor Inputs

A full production run is generally run in volumes, but may be accomplished in one run. If it is run in volumes, the simulation's memory, contained in an array called ISPACE, is saved on Hold Files to be used in starting the next volumes. The length of a volume is controlled by the fourth, fifth, and sixth run parameters (see Section (b) below). A large production run will use about 2,000 (3,720 octal) CP seconds and about 120 (170 octal) I/O seconds, thus running at priority P10. Volumes of about 30,000 events each will use about 200 (310 octal) CP seconds and 10 I/O seconds, thus running at priority P60. A large run could take between eight and twelve of these volumes. For an explanation of these job card parameters, see Appendix D or an AFWL SYSBULL.

```
MADEM,ST176,T30,I050,P66,EC150.            MADEM PREPROCESSOR (EXAMPLE)
ACCOUNT   MADEM,********-ZZZ,BDM,703-821-4223.          B MACALEER
COMMENT.  **************************************
COMMENT.  *                                    *
COMMENT.  * MADEM PREPROCESSOR (EXAMPLE):      *
COMMENT.  *     PLANS RED RAID                 *
COMMENT.  *     READS DATFILE, UOIL INPUT      *
COMMENT.  *     GENERATES ISPACE               *
COMMENT.  *     SAVES ISPACE ON HOLD FILES     *
COMMENT.  *                                    *
COMMENT.  * FILES:                             *
COMMENT.  *    TAPE4 - HISTORY FILE            *
COMMENT.  *    TAPE7 - UOIL INPUT              *
COMMENT.  *    TAPE8 - DATFILE INPUT           *
COMMENT.  *    TAPE10 - FIRST HOLD FILE        *
COMMENT.  *    TAPE11 - SECOND HOLD FILE       *
COMMENT.  *    TAPE14 - PRINTED PLANNER OUTPUT *
COMMENT.  *                                    *
COMMENT.  **************************************
REQUEST,TAPE4,*PF.
REQUEST,TAPE10,*PF.
REQUEST,TAPE11,*PF.
ATTACH,TAPE7,UOILEXAMPLE,ID=WDNA14V6.
ATTACH,TAPE8,DATFILEEXAMPLE,ID=WDNA14V6.
ATTACH,INITBIN,MADEMINITBIN,ID=WDNA14V6.
LDSET,PRESET=ZERO.
LOAD,INITBIN.
EXECUTE.
REWIND,TAPE4,TAPE10,TAPE11,TAPE14.
COMMENT.  **************************************
COMMENT.  * SAVE HISTORY FILE AND HOLD FILES   *
COMMENT.  **************************************
CATALOG,TAPE4,EXAMPLEHISTPLAN,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEPLAN1,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEPLAN2,ID=WDNA14V6,RP=999.
COMMENT.  **************************************
COMMENT.  *  GET PRINTED OUTPUT                *
COMMENT.  **************************************
COPYBF,TAPE14,OUTPUT.
COMMENT.  **************************************
COMMENT.  * FIRST INPUT CARD IS MANDATORY AND  *
COMMENT.  * HOLDS 6 PARAMETERS:                *
COMMENT.  *    2. MUST BE 1 FOR PREPROCESSOR   *
COMMENT.  *    2. SIZE OF ISPACE (50000)       *
COMMENT.  *    3. MAX NO. PLAYERS ON ONE SIDE  *
COMMENT.  *    4. DUMMY VALUE (25)             *
COMMENT.  *    5. DUMMY VALUE (999999)         *
COMMENT.  *    6. DUMMY VALUE (1)              *
COMMENT.  **************************************
EXIT.
```

Figure VI-8. Preprocessor Job Control Language

```
COMMENT.  ***************************************
COMMENT.  * WE HAVE BOMBED, GET OUTPUT ANYWAY   *
COMMENT.  ***************************************
DMP,100,7200.
DMPECS,0,1000
REWIND,TAPE14,TAPE6.
COPYBF,TAPE14,OUTPUT.
COPYBF,TAPE6,OUTPUT.
&         EOR
1,50000,600,25,999999,1
#         EOI
```

Figure VI-8. Preprocessor Job Control Language (Continued)

To run the main processor for our example case, the following permanent files must reside on the AFWL system:

MADEMRUNBIN	-	Executable main processor program
EXAMPLEPLAN1	-	First Hold File, created by the preprocessor
EXAMPLEPLAN2	-	Second Hold File, created by the preprocessor

The last two files should be taken care of by the preprocessor, and normally should not concern the user.

a. Main Processor Job Control Language

The production run job control stream in figure VI-9 will execute the MADEM main processor. The COMMENT cards are for your information only and may be omitted. The three REQUEST cards allocate permanent file space for the History File (TAPE4) and the Hold Files. The ATTACH cards access the permanent files listed above. After executing RUNBIN, the History File and Hold Files are saved permanently. The event trace messages in TAPE6 are sent to the printer. If more than one raid was called for, TAPE14 will have plan output to be sent to the printer as well. Everything after the EXIT card is only executed if the system abnormally aborts the job stream. In this case debug information will be sent to the printer.

If the main processor is run in more than one volume, use the volume cards listed in figure VI-10. There are eight sets of volume cards listed, the first of which is already in the JCL. To run volume 2, just replace the volume 1 cards in the job stream with the respective volume 2 cards. This process can be continued for as many volumes as is necessary to complete the run. Just continue to replace volume cards with the next volume cards.

b. Main Processor Run Parameters

The next to the last card in the job control stream is the Run Parameters Card. It includes six parameters:

(1) a two for RUNBIN

```
MADEM,ST176,T300,I0100,P60,EC305.             MADEM PRODUCTION RUN (EXAMPLE)
ACCOUNT  MADEM,******-ZZZ,BDM,703-821-4223.        B MACALEER
COMMENT.  **************************************
COMMENT.  *                                    *
COMMENT.  *  MADEM PRODUCTION RUN (EXAMPLE)     *
COMMENT.  *                                    *
COMMENT.  *  FILES:                            *
COMMENT.  *    TAPE4 - HISTORY FILE            *
COMMENT.  *    TAPE6 - PRINTED EVENT TRACE     *
COMMENT.  *    TAPE10 - FIRST HOLD FILE        *
COMMENT.  *    TAPE11 - SECOND HOLD FILE       *
COMMENT.  *    TAPE14 - PLAN OUTPUT (IF ANY)   *
COMMENT.  *                                    *
COMMENT.  **************************************
REQUEST,TAPE4,*PF.
REQUEST,TAPE10,*PF.
REQUEST,TAPE11,*PF.
COMMENT.  **************************************
COMMENT.  *  VOLUME 1, RUN TYPE EXAMPLE        *
COMMENT.  **************************************
ATTACH,TAPE15,EXAMPLEPLAN1,ID=WDNA14V6.
ATTACH,TAPE16,EXAMPLEPLAN2,ID=WDNA14V6.
ATTACH,RUNBIN,MADEMRUNBIN,ID=WDNA14V6.
LDSET,PRESET=ZERO.
LOAD,RUNBIN.
EXECUTE,,PL=20000.
REWIND,TAPE4,TAPE6,TAPE10,TAPE11,TAPE14.
COMMENT.  **************************************
COMMENT.  *  SAVE HISTORY FILE AND HOLD FILES  *
COMMENT.  **************************************
CATALOG,TAPE4,EXAMPLEHISTVOL1,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEVOL1A,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEVOL1B,ID=WDNA14V6,RP=999.
COMMENT.  **************************************
COMMENT.  *  GET PRINTED OUTPUT                *
COMMENT.  **************************************
COPYBF,TAPE14,OUTPUT.
COPYBF,TAPE6,OUTPUT.
COMMENT.  **************************************
COMMENT.  * FIRST INPUT CARD IS MANDATORY AND  *
COMMENT.  * HOLDS 6 PARAMETERS:                *
COMMENT.  *    1. MUST BE 2 FOR RUNBIN         *
COMMENT.  *    2. SIZE OF ISPACE (100000)      *
COMMENT.  *    3. MAX NO. PLAYERS ON ONE SIDE  *
COMMENT.  *    4. MAX CPU TIME OF THIS VOLUME  *
COMMENT.  *    5. MAX GAME TIME OF THIS VOLUME *
COMMENT.  *    6. MAX NO OF EVENTS FOR THIS VOL *
COMMENT.  **************************************
EXIT.
```

Figure VI-9. Main Processor Job Control Language

```
COMMENT.  ***************************************
COMMENT.  * WE HAVE BOMBED, GET OUTPUT ANYWAY   *
COMMENT.  ***************************************
DMP,100,7200.
DMPECS,0,1000.
REWIND,TAPE14,TAPE6.
COPYBF,TAPE14,OUTPUT.
COPYBF,TAPE6,OUTPUT.
&         EOR
2,100000,600,235,00000,20000
#         EOI
```

Figure VI-9. Main Processor Job Control Language (Continued)

```
COMMENT.  ***************************************
COMMENT.  * VOLUME 1, RUN TYPE EXAMPLE          *
COMMENT.  ***************************************
ATTACH,TAPE15,EXAMPLEPLAN1,ID=WDNA14V6.
ATTACH,TAPE16,EXAMPLEPLAN2,ID=WDNA14V6.
CATALOG,TAPE4,EXAMPLEHISTVOL1,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEVOL1A,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEVOL1B,ID=WDNA14V6,RP=999.

COMMENT.  ***************************************
COMMENT.  * VOLUME 2, RUN TYPE EXAMPLE          *
COMMENT.  ***************************************
ATTACH, TAPE15,EXAMPLEVOL1A,ID=WDNA14V6.
ATTACH,TAPE16,EXAMPLEVOL1B,ID=WDNA14V6.
CATALOG,TAPE4,EXAMPLEHISTVOL2,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEVOL2A,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEVOL2B,ID=WDNA14V6,RP=999.

COMMENT.  ***************************************
COMMENT.  *  VOLUME 3, RUN TYPE EXAMPLE         *
COMMENT.  ***************************************
ATTACH,TAPE15,EXAMPLEVOL2A,ID=WDNA14V6.
ATTACH,TAPE16,EXAMPLEVOL2B,ID=WDNA14V6.
CATALOG,TAPE4,EXAMPLEHISTVOL3,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEVOL3A,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEVOL3B,ID=WDNA14V6,RP=999.

COMMENT.  ***************************************
COMMENT.  * VOLUME 4, RUN TYPE EXAMPLE          *
COMMENT.  ***************************************
ATTACH,TAPE15,EXAMPLEVOL3A,ID=WDNA14V6.
ATTACH,TAPE16,EXAMPLEVOL3B,ID=WDNA14V6.
CATALOG,TAPE4,EXAMPLEHISTVOL4,ID=WDNA14V6,RP=999.
CATALOG,TAPE10,EXAMPLEVOL4A,ID=WDNA14V6,RP=999.
CATALOG,TAPE11,EXAMPLEVOL4B,ID=WSNA14V6.RP=999.
```

Figure VI-10. Volume Cards

(2) size of ISPACE (100,000)

(3) maximum number of players on either side (600)

(4) maximum CPU time (in decimal seconds) of this volume (235)

(5) maximum game time (in decimal seconds) of this volume (999999)

(6) maximum number of events for this volume (20,000)

This particular run is set to run to 20,000 EVENTS, since game time and CPU time are set high. To get even volumes, it is best to base the length of the volumes on number of events or CPU time rather than game time. To use only one of these three volume length control parameters, set the other two unusually high so that the desired parameter will stop the volume first.

3. Post Processor Input

After all volumes of the main processor have run, the post processor may be run to summarize the results of the simulation. The preprocessor and each volume of the main processor saved a history file. These history files are used by the post processor. To run the post processor for our four volume example the following permanent files must reside on the AFWL system:

MADEMHISTBIN	-	post processor executable program.
EXAMPLEHISTPLAN	-	preprocessor history file
EXAMPLEHISTVOL1	-	volume 1 history file
EXAMPLEHISTVOL2	-	volume 2 history file
EXAMPLEHISTVOL3	-	volume 3 history file
EXAMPLEHISTVOL4	-	volume 4 history file

If the preprocessor and the main processor were run correctly, then all the history files should be there.

a. Post Processor Job Control Language

The post processor job control stream in figure VI-11 will produce the MADEM post processor summary. The COMMENT cards are for your information only and may be omitted. The ATTACH cards access the permanent files listed above. Only use ATTACH cards for the files needed. That is,

```
MADEM,ST176,T20,I060,P66.                    MADEM HISTORY PROCESSING (EXAMPLE)
ACCOUNT  MADEM,******-ZZZ,BDM,703-821-4223.  B MACALEER
COMMENT.  ***************************************
COMMENT.  *                                     *
COMMENT.  * MADEM HISTORY PROCESSING (EXAMPLE)  *
COMMENT.  *                                     *
COMMENT.  * TAPE4:  CONCATENATION OF HISTORY    *
COMMENT.  *         FILES FROM PREPROCESSOR AND *
COMMENT.  *         ALL VOLUMES                 *
COMMENT.  *                                     *
COMMENT.  ***************************************
ATTACH,HISTBIN,MADEMHISTBIN,ID=WDNA14V6.
ATTACH,PLAN,EXAMPLEHISTPLAN,ID=WDNA14V6.
ATTACH,V1,EXAMPLEHISTVOL1,ID=WDNA14V6.
ATTACH,V2,EXAMPLEHISTVOL2,ID=WDNA14V6.
ATTACH,V3,EXAMPLEHISTVOL3,ID=WDNA14V6.
ATTACH,V4,EXAMPLEHISTVOL4,ID=WDNA14V6.
ATTACH,V5,EXAMPLEHISTVOL5,ID=WDNA14V6.
ATTACH,V6,EXAMPLEHISTVOL6,ID=WDNA14V6.
ATTACH,V7,EXAMPLEHISTVOL7,ID=WDNA14V6.
ATTACH,V8,EXAMPLEHISTVOL8,ID=WDNA14V6.
COPYBR,PLAN,TAPE4.
COPYBR,V1,TAPE4.
COPYBR,V2,TAPE4.
COPYBR,V3,TAPE4.
COPYBR,V4,TAPE4.
COPYBR,V5,TAPE4.
COPYBR,V6,TAPE4.
COPYBR,V7,TAPE4.
COPYBR,V8,TAPE4.
REWIND,TAPE4.
LDSET,PRESET=ZERO.
LOAD,HISTBIN.
EXECUTE.
EXIT.
COMMENT.  ***************************************
COMMENT.  * WE HAVE BOMBED, PRINT HISTORY INPUT *
COMMENT.  ***************************************
REWIND,TAPE4.
COPYSBF,TAPE4,OUTPUT.
&         EOR
CONVENTIONAL   1978      EXAMPLE CASE
39000.,999999999.,999999999.,999999999.,999999999.
#         EOI
```

Figure VI-11. Post Processor Job Control Language

if only four volumes of the main processor were run, then delete the ATTACH cards for volumes five thru eight. Once all files are attached, the COPYBR cards concatenate all the history files into one local file called TAPE4. Everything after the EXIT card is only executed if the system abnormally aborts the job stream. In this case, the input (TAPE4) is printed to use as a debugging tool.

When a run is complete through the post processor, there will be some permanent files left on the AFWL system that are no longer needed. These files should be purged using the job control stream that is listed in Figure VI-12. Again, use only the purge cards corresponding to the number of volumes that were run.

b. Post Processor Run Parameters

The two cards before the last card are Run Parameter Cards. The first parameter card is an up to 70 character header that will appear on the output summary. The second parameter card holds five parameters. Each of these five parameters represents a time in the simulation when summary statistics are required. The time is a real number and is in seconds. In this example we are requesting only one set of summary statistics, at game time 10.8 hours (39000.0 seconds) which is after the end of the simulation. Therefore, we will only get final results with no intermediary statistics. When more than one "snapshot" is requested, the snapshots are not cumulative; each snapshot covers all events since the previous snapshot. Up to five snapshots are allowed. If less than five are needed, it is recommended that dummy values be used (999999999) to suppress further processing, as was done in this example.

D. OUTPUTS

Each stage of the MADEM simulation produces some useable output. The preprocessor produces the Red raid plans, the main processor produces an event trace, and the post processor produces a summary of the events of the simulation.

```
MADEM,ST176,T40,I040,P66.          PURGE HOLD AND HISTORY FILES (EXAMPLE)
ACCOUNT  MADEM,               ,BDM,703-821-4223.   B MACALEER
COMMENT.  **************************************
COMMENT.  * PURGE HOLD FILES FOR EXAMPLE RUN    *
COMMENT.  **************************************
PURGE,PL1,EXAMPLEPLAN1,ID=WDNA14V6,LC=1.
PURGE,PL2,EXAMPLEPLAN2,ID=WDNA14V6,LC=1.
PURGE,V1A,EXAMPLEVOL1A,ID=WDNA14V6,LC=1.
PURGE,V1B,EXAMPLEVOL1B,ID=WDNA14V6,LC=1.
PURGE,V2A,EXAMPLEVOL2A,ID=WDNA14V6,LC=1.
PURGE,V2B,EXAMPLEVOL2B,ID=WDNA14V6,LC=1.
PURGE,V3A,EXAMPLEVOL3A,ID=WDNA14V6,LC=1.
PURGE,V3B,EXAMPLEVOL3B,ID=WDNA14V6,LC=1.
PURGE,V4A,EXAMPLEVOL4A,ID=WDNA14V6,LC=1.
PURGE,V4B,EXAMPLEVOL4B,ID=WDNA14V6,LC=1.
PURGE,V5A,EXAMPLEVOL5A,ID=WDNA14V6,LC=1.
PURGE,V5B,EXAMPLEVOL5B,ID=WDNA14V6,LC=1.
PURGE,V6A,EXAMPLEVOL6A,ID=WDNA14V6,LC=1.
PURGE,V6B,EXAMPLEVOL6B,ID=WDNA14V6,LC=1.
PURGE,V7A,EXAMPLEVOL7A,ID=WDNA14V6,LC=1.
PURGE,V7B,EXAMPLEVOL7B,ID=WDNA14V6,LC=1.
PURGE,V8A,EXAMPLEVOL8A,ID=WDNA14V6,LC=1.
PURGE,V8B,EXAMPLEVOL8B,ID=WDNA14V6,LC=1.

COMMENT.  **************************************
COMMENT.  * PURGE HISTORY FILES FOR EXAMPLE RUN *
COMMENT.  **************************************
PURGE,HP,EXAMPLEHISTPLAN,ID=WDNA14V6,LC=1.
PURGE,H1,EXAMPLEHISTVOL1,ID=WDNA14V6,LC=1.
PURGE,H2,EXAMPLEHISTVOL2,ID=WDNA14V6,LC=1.
PURGE,H3,EXAMPLEHISTVOL3,ID=WDNA14V6,LC=1.
PURGE,H4,EXAMPLEHISTVOL4,ID=WDNA14V6,LC=1.
PURGE,H5,EXAMPLEHISTVOL5,ID=WDNA14V6,LC=1.
PURGE,H6,EXAMPLEHISTVOL6,ID=WDNA14V6,LC=1.
PURGE,H7,EXAMPLEHISTVOL7,ID=WDNA14V6,LC=1.
PURGE,H8,EXAMPLEHISTVOL8,ID=WDNA14V6,LC=1.
#         EOI
```

Figure VI-12. Post Run Purging JCL

1. Preprocessor Output

The preprocessor produces three types of printed output: an echo of the Data Base File, an echo of the User Input Lanaguage File, and a description of the Red attack plan for raid one. In our example case, the Red attack consisted of one raid, two waves, as determined by the UOIL File.

The first part of the red planner output is a list of flight action codes with their respective descriptions. These codes are used in the remainder of the output to indicate the movements and actions of each flight in the wave. These Flight Action Codes are also listed below:

FLIGHT ACTION CODES:

1 JAMMER ON
2 JAMMER OFF
3. PROFILE CHANGE POINT
4. ECM ORBIT
5. INTERCEPT ORBIT
6. RENDEVU POINT
7. GROUND ATTACK ORBIT
8. ASM LAUNCH
9. STOP ORBIT, NEWCOURSE
10. LAND
11. CHANGE COURSE

These actions may be taken at the end of each leg of a flight path.

The rest of the planner output consists of detailed descriptions of each wave in raid one, beginning with the last wave. For each target of the Red attack, its hex location is given with a description of the flight plans for each formation assigned to the target. There is one line of output for each action taken by each flight. There are twelve fields on each line of output (repetition is implied with blank fields). These fields are described below:

(1) Target Type - Numeric code indicating the type of target. See Appendix E for an explanation of the codes.

(2) Target Unit Number - Unit number of a specific target. These unit numbers are derived from the UOIL File. If the unit number is negative, that means the target is passive.

(3) Target Location - Hex location of the target.

(4) Formation Type - Type of formation assigned to the target. These formation types are defined by the data base file.

(5) Flight Unit Number - Unit number of a flight in the formation. These unit numbers are created by the simulation.

(6) Flight Type - Indicates the type of flight as defined by the Data Base File.

(7) Number of Aircraft - Indicates how many aircraft are in the flight.

(8) Aircraft Type - Numeric code indicating the type of aircraft in the flight. All flights are homogeneous. See Appendix E for an explanation of the codes.

(9) Airbase Unit Number - Unit number of the airbase that the flight originated from. This number comes from the UOIL File.

(10) Airbase Location - Hex location of the airbase that the flight originated from.

(11) Action Hex - Hex location at which the action described in the next field is to take place.

(12) Action Code - Action codes, described in the first page of planner output, that describes flight movements at the given hex locations.

a. First Wave Attack Plan

The first wave attack plan which results from the first wave attack specification input by the user is summarized and output by the preprocessor. The first wave plan for this scenario output by the preprocessor is shown in figure VI-13. The assignment of flights from various airbases to formations and subsequently to blue targets is output along with the flight plans for each flight.

The first wave attack plan shown in figure VI-13 is illustrated in figure VI-14. Figure VI-14 shows the courses to target planned for the first wave. These courses indicate planned attacks on HAWK and Nike-Hercules batteries in the attack corridors.

b. Second Wave Attack Plan

A partial listing of the second wave attack plan output is shown in figure VI-15. The same plan is illustrated in figure VI-16. Both figures indicate planned attacks on HAWK batteries near the attack corridors and upon airbases and passive targets deep in blue airspace. Several large formation rendevous points are also indicated within red airspace.

2. Main Processor Output

The main processor produces a printed event trace while the simulation is in progress. Only pertinent events produce an event trace. Since about ninety percent of the simulation events are trival (but necessary) only about one event in ten produces a printed trace.

The event trace messages are explained in Appendix B. To the left of each event message is the game time, in seconds, at which the event occurred. See figure VI-17 for a sample event trace.

3. Post Processor Output

The MADEM postprocessor outputs a variety of information designed to aid analysts in computing measures of air defense effectiveness. These outputs are in the form of tables which contain the following information:

(1) Units created by type

(2) Red attacks on Blue players by aircraft type

RAID 1 WAVE 1 TIME 23400.00

TARGET TYPE	TARGET UNIT NO	TARGET LOCATION	FORMATION TYPE	FLIGHT UNIT NO	FLIGHT TYPE	NO OF AIRCRAFT	AIRCRAFT TYPE	AIRBASE TYPE	AIRBASE LOCATION	ACTION HEX	ACTION CODE
180	11	7777525	1	833	1	10	460	19	7774233	7774225	6
										7774162	3
										7775222	11
										7777525	7
										7777526	3
										7774233	10
				842	6	4	420	19	7774233	7774225	6
										7774162	3
										7775222	11
										7777525	7
										7777526	3
										7774233	10
170	9	7752352	3	850	4	4	440	21	7741167	7741532	6
										7752362	3
										7752352	7
										7752343	3
										7741167	10
170	8	7775623	3	858	4	4	440	19	7774233	7774225	6
										7774523	3
										7775623	7
										7774141	3
										7774233	10
170	28	7752337	3	867	4	4	440	21	7741167	7741532	6
										7774547	3
										7752337	7
										7752321	3
										7741167	10
			3	878	4	4	440	21	7741167	7741532	6
										7752215	3
										7752337	7
										7752321	3
										7741167	10

Figure VI-13. Result Of Red Theater Plans

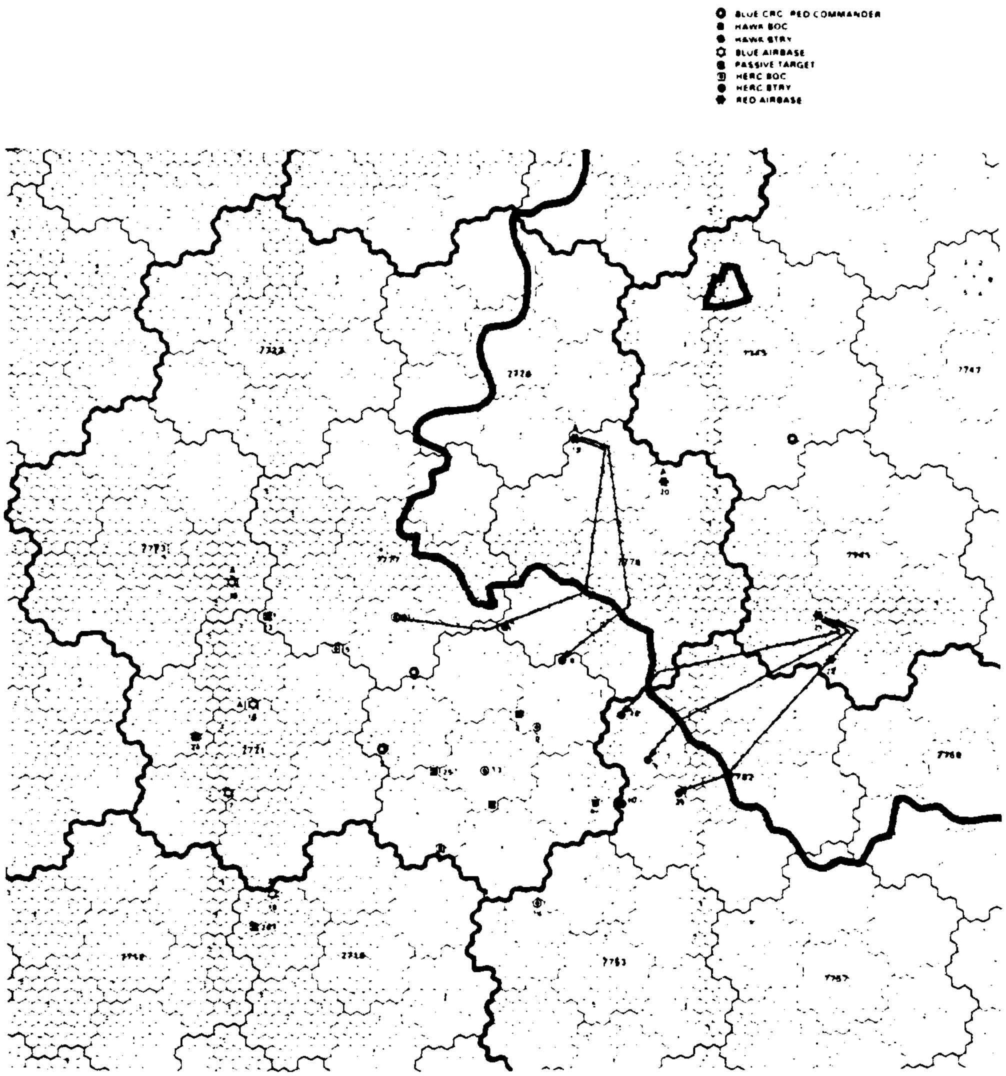


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Figure VI-14. First Wave Attack Plan

RAID 1 WAVE 2 TIME 23400.00

TARGET TYPE	TARGET UNIT NO	TARGET LOCATION	FORMATION TYPE	FLIGHT UNIT NO	FLIGHT TYPE	NO OF AIRCRAFT	AIRCRAFT TYPE	AIRBASE TYPE	AIRBASE LOCATION	ACTION HEX	ACTION CODE
34	-11	7775754	1	465	1	16	460	22	7741513	7741575	6
										7752366	3
										7752351	11
										7775754	7
										7775745	3
										7741513	10
				458	6	4	420	22	7741513	7741575	6
										7752366	3
										7752351	11
										7775754	7
										7775745	3
										7741513	10
			1	457	1	16	460	22	7741513	7741575	6
										7752362	3
										7752314	11
										7775754	7
										7775745	3
										7741513	10
				455	6	4	420	22	7741513	7741575	6
										7752362	3
										7752314	11
										7775754	7
										7775745	3
										7741513	10
210	-25	7775122	1	452	1	16	460	21	7741167	7741532	6
										7752362	3
										7752314	11
										7775122	7
										7775713	3
										7741167	10
				446	6	4	420	21	7741167	7741532	6
										7752362	3
										7752314	11
										7775122	7
										7775713	3
										7741167	10

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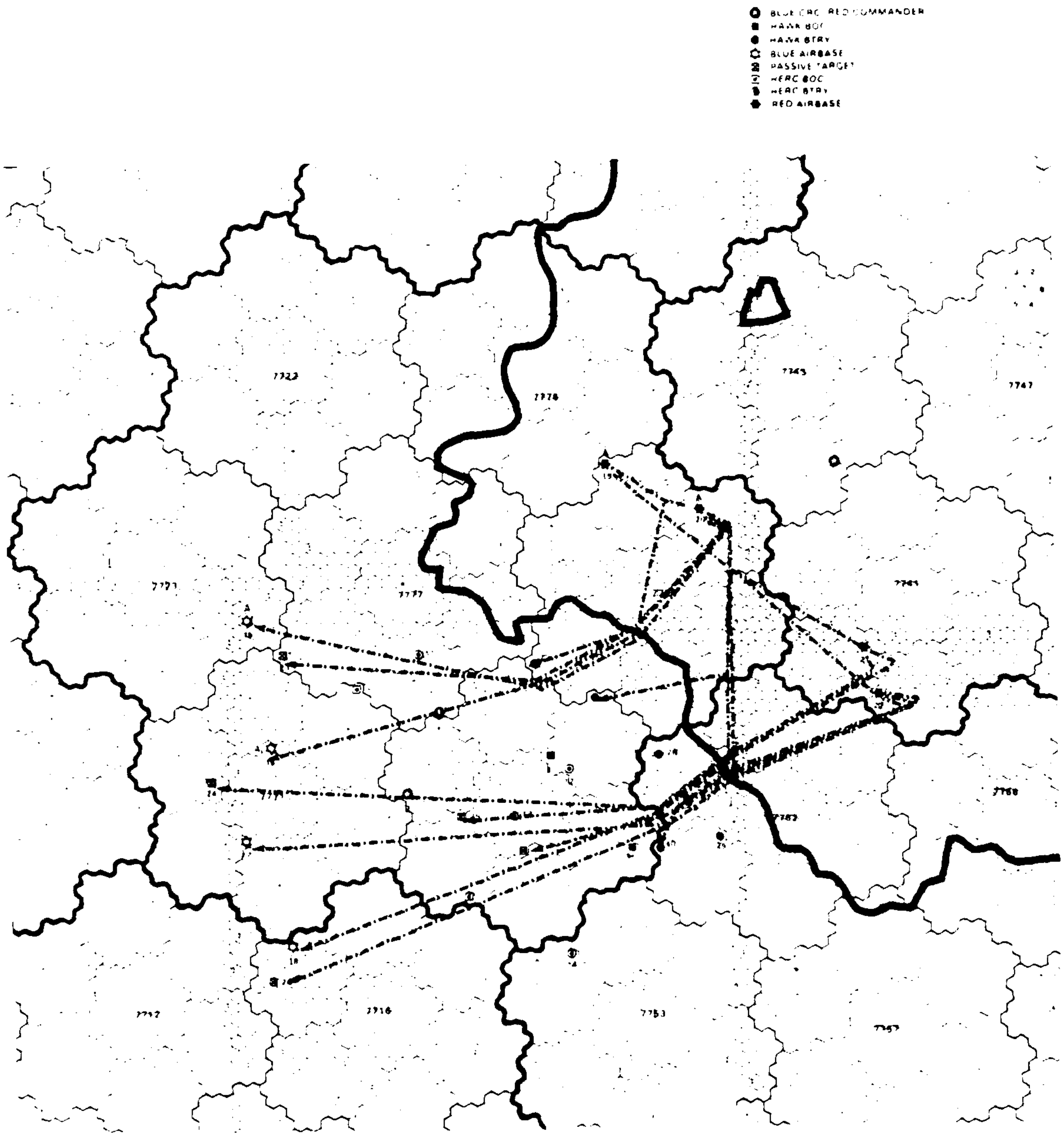
Figure VI-15. Result Of Red Theater Plans



4368/79W

Figure VI-16. Second Wave Attack Plan

SAMPLE EVENT LISTING

MADEM

```
A/R       5056 LAUNCHS INTRCPTR        60366
                                          UNIT 850 DIGESTS INFO ON FLIGHT 28434
                                          UNIT 593 DIGESTS INFO ON FLIGHT 36227
CRC       2765 ACKS RLSE OF TGT        31905 BY BTN   4135
                                          UNIT 581 MOVING LFIGHT 34546 FROM FOO TO ADIL
CRC       3014 ACKS RLSE OF TGT        32660 BY BTN   5007
                                          UNIT 541 RECEIVES ORDER TO ENGAGE FLIGHT 31833 WITH
                                             2 FIRE UNITS
                                          UNIT 548 DIGESTS INFO ON FLIGHT 28972
CRC       3014 ACKS RLSE OF TGT        31905 BY BTN   4900
CRC       3014 ASSIGNS 31905 TO BTN  5007
                                          UNIT 601 MASKED FROM 33117
CRC       2518 ASSIGNS 33117 TO BTN  3501
                                          UNIT 585 MASKED FROM 33117
                                          FIRE UNIT 9556 OF BTRY 591 LOCKED ON FLIGHT 30615
                                          FIRE UNIT 9556 OF BTRY 591 FIRES ON FLIGHT 30615 (    )
                                          FIRE UNIT 9561 OF BTRY 591 LOCKED ON FLIGHT 30615
                                          FIRE UNIT 9561 OF BTRY 591 FIRES ON FLIGHT 30615 (    )
                                          UNIT 597 DIGESTS INFO ON FLIGHT 32261
                                          UNIT 597 MOVING LFIGHT 30109 FROM FOQ TO ADIL
CRC       2518 ACKS RLSE OF TGT        32050 BY BTN  3501
                                          UNIT 601 DIGESTS INFO ON FLIGHT 30166
                                          UNIT 558 DIGESTS INFO ON FLIGHT 32947
                                          UNIT 541 DIGESTS INFO ON FLIGHT 35463
INT       50094 FIRES ON 38304
```

Figure VI-17. Sample Event Listing

(3) Red attacks on Blue passive targets by aircraft type

(4) Acquisitions of Red flights by blue units

(5) Red flights engaged by Blue defense units

(6) Red aircraft killed by Blue defense units

(7) Missiles fired by unit type

These table are displayed in three formats. The first format is used only for units created and is illustrated in Figure VI-18. The second format type is used for Red attacks on Blue players, Red attacks on Blue passive targets, and Red aircraft killed by Blue defense units. This format is illustrated in figure VI-17. The "231" in the uper left hand corner of the output matrix in Figure VI-19 is an internal matrix code number. It can be ignored in the analysis of MADEM output. Column 1 and Row 1 of the matrix in Figure VI-19 indicate the unit code numbers of attacking red flights and defending Blue units respectively.

Figure VI-20 illustrates the format used to display acquisitions of Red flights by Blue units, Red flights engaged by Blue units,and missiles fired. This format is identical to figure VI-19 except for the addition of row and column totals indicated by a 9999 in Row 1 and Column 1.

TYPE	NUMBER
34	1
130	2
150	2
160	2
170	6
180	4
210	4
220	8
401	12
420	11
440	16
460	11

NOTE: SEE APPENDIX E FOR UNIT CODE DEFINITIONS

Figure VI-18. Number Of Units Created By Type

DOEE	DOER		
231	440	420	460
170	6	0	0
401	10	28	0
220	3	0	4

NOTE: DOER = SUBJECT OF AN ACTION
DOEE = OBJECT OF AN ACTION
SEE APPENDIX E FOR DOER/DOEE UNIT CODE DEFINITIONS

Figure VI-19. Number Of Red Attacks On Blue Players

DOEE	DOER				
112	9999	150	130	160	401
9999	0	38	36	34	11
440	45	16	14	12	3
460	38	11	11	11	5
420	36	11	11	11	3

NOTE: DOER = SUBJECT OF AN ACTION
DOEE = OBJECT OF AN ACTION
SEE APPENDIX E FOR DOER/DOEE UNIT CODE DEFINITIONS
9999 = COLUMN/ROW TOTAL

Figure VI-20. Acquisitions Of Red FLTS By Blue Units

APPENDIX A
USER GUIDE TO HEXAGONAL COORDINATE SYSTEM

A. INTRODUCTION

The purpose of this appendix is to give a brief explanation of the Hexagonal Coordinate System (HECS) used in MADEM. For a more detailed discussion, including the rationale for using this coordinate system, the reader is referred to the draft technical report, "An Integrated Coordinate System for Combat Modeling", BDM/W-78-297-TR, 19 May 1978.

B. STRUCTURE OF HECS

The Hexagonal Coordinate System is based upon the concept of tiling the plane with a grid of regular hexagons and aggregating them into successively larger clusters of 7. A single regular hexagon in the grid is called a level 0 hex. A cluster of 7 level 0 hexes, one regular hexagon together with its 6 neighboring hexagons, is called a level 1 hex. This process of aggregation can be iterated, and in general a cluster of 6 level n hexes surrounding a central level n hex forms a level n + 1 hex.

The higher level hexes are not true regular hexagons, but they remain approximately hexagonal in shape. Hexes at any level mesh together to tile the plane.

C. MADEM AIRSPACE

The MADEM airspace is represented by a single level 12 hex. This hex contains 7 level 11 hexes, each of which contains 7 level 10 hexes, and so on down to the level 0 hexes, which are regular hexagons. The grid is oriented so that the level 0 hexes have a pair of opposite edges running west to east. The lowest level Hex used in MADEM is a level 6 Hex which measures 9.45km from face to face. Each unit (including Flights) is located in a level 6 Hex.

HEX LEVEL		NO. OF	HEX DIAMETER	HEX AREA
DEC	OCT	HEX DIGITS	(KM)	$D^2 \sqrt{3}/2$
13	15	0	8575.	63,700,000
12	14	1	3240.	9,100,000
11	13	2	1225.	1,300,000
10	12	3	463.	185,600
9	11	4	175.	26,500
8	10	5	66.1	3,790
7	7	6	25.	541
6	6	7	9.45	77

Figure A-1. Hex Specifications

D. HEX ADDRESSES

A hex address is a string of one to twelve digits which identifies a specific hex. It is a way of encoding both the location and the level of a hex. Each digit in a hex address is from 1 through 7 inclusive. The leftmost digit identifies which of the 7 level 11 hexes contains this hex. If there are no further digits, then the hex address corresponds to this level 11 hex. The next digit identifies which of the 7 level 10 hexes comprising the level 11 hex contains the hex in question. This classification procedure continues all the way down to the level of the specificed hex. The hex address of a level 0 hex will have 12 digits, and in general the following equation is satisfied:

$$L + D = 12$$

where L is the level of the hex and D is the number of digits in its hex address.

The numbering scheme for a level 7 cluster of 7 level 6 hexes is shown in Figure A-2. Note that 7 indicates the center hex and 1 indicates the hex directly north of center. The rest of the numbering scheme is chosen for computational convenience. The numbering scheme for a level 8 cluster of 7 level 7 hexes is shown in A-3. The scheme is essentially the same except that there has been a slight counterclockwise rotation of the positions of the hexes numbered 1 through 6. For clusters of higher and higher level hexes, the same numbering scheme is used, but the relative positions of the outer hexes rotate approximately 19 degrees counterclockwise for each increase in level.

Figure A-4 illustrates the combined numbering scheme for level 6 hexes within a level 8 hex. The two digits shown would be the last 2 digits in the hex addresses for these level 6 hexes. Note that the shaded level 6 hex is numbered 35 because it is in the 5 position within the number 3 level 7 hex in the level 8 cluster. Figure A-5 shows a few sample hex

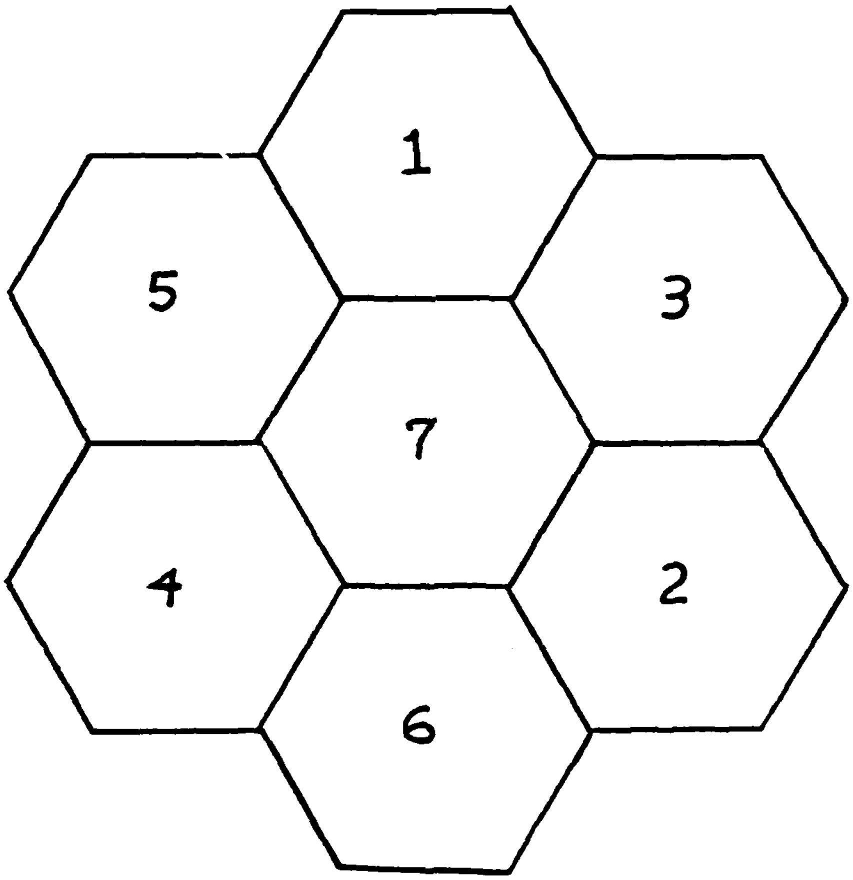


Figure A-2. Numbering Scheme For Level 6 Hexes Within A Level 7 Cluster

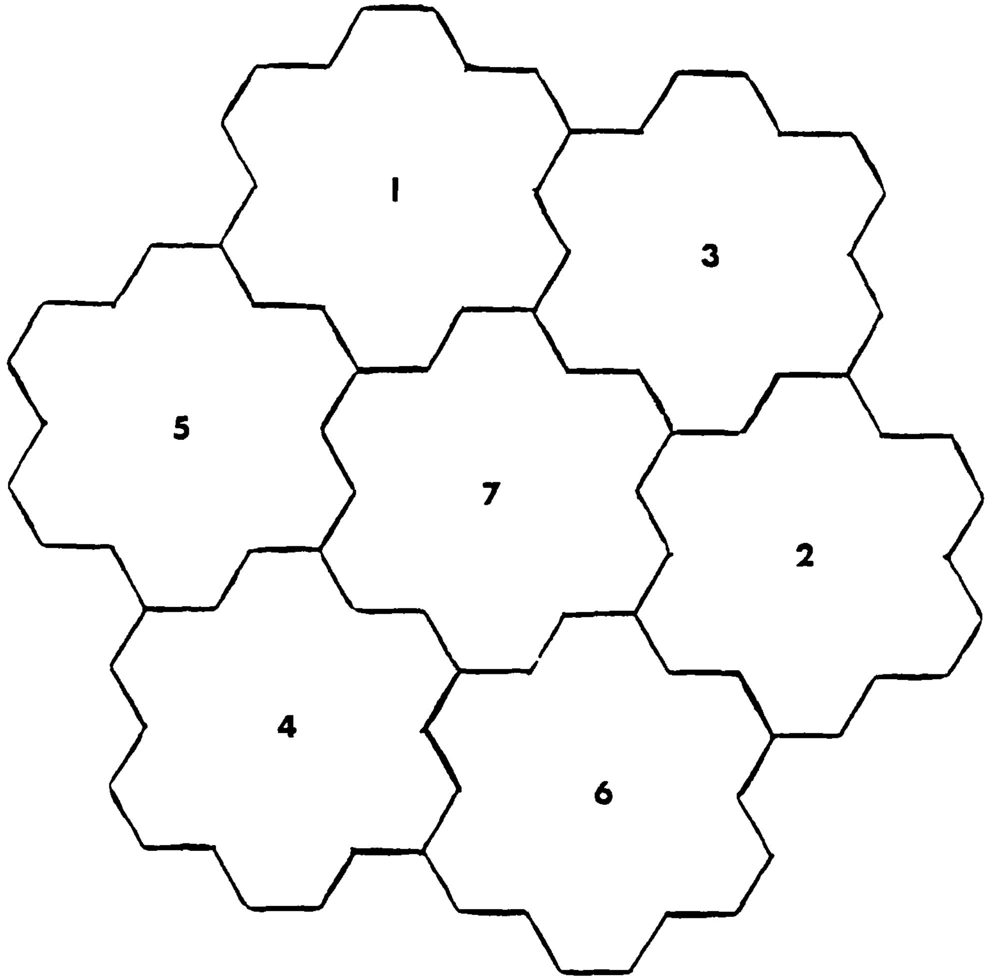


Figure A-3. Numbering Scheme For Level 1 Hexes Within A Level 2 Cluster

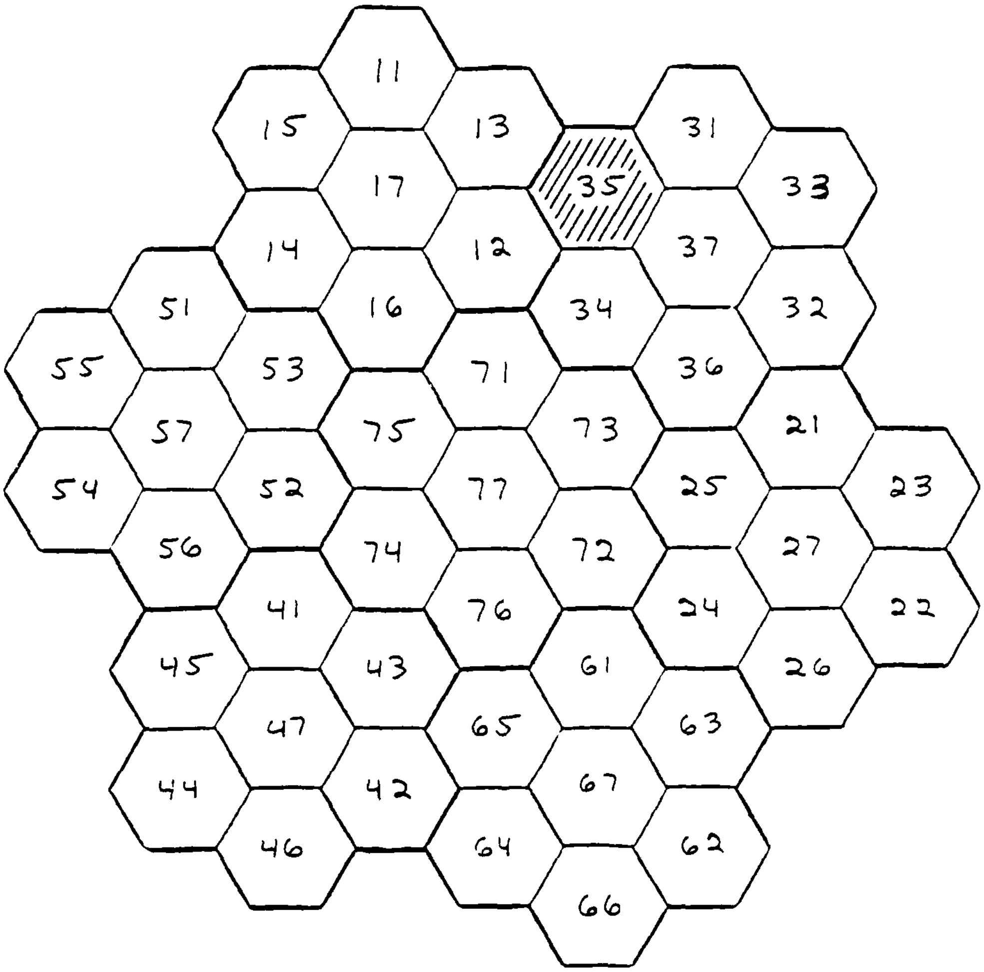


Figure A-4. Combined Numbering Scheme For Level 6 Hexes
Within A Level 8 Cluster

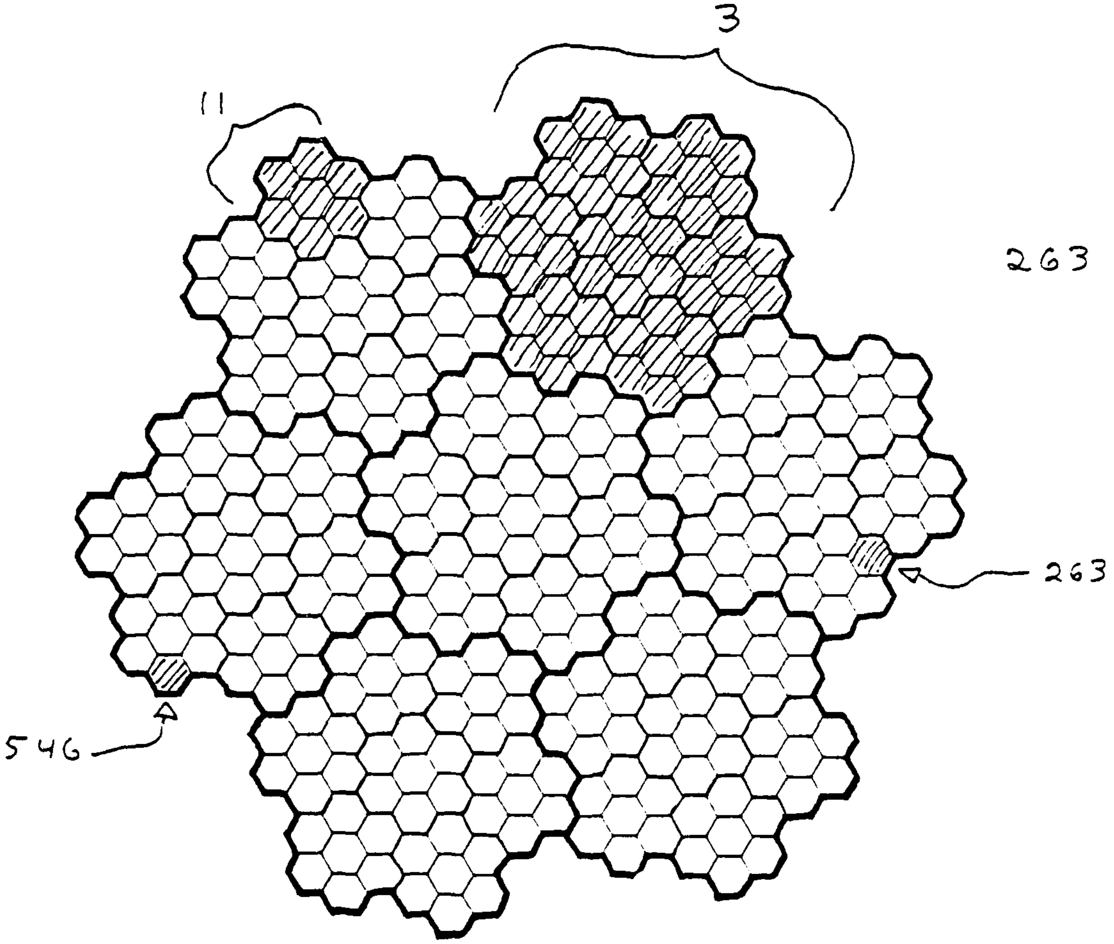


Figure A-5. Sample Hex Addresses Within a Level 9 Cluster

addresses in a level 9 cluster. Actually each address would be preceded by a digit identifying the particular level 9 hex illustrated.

E. HEX DIRECTIONS

Movement is always in the direction of one of the six surrounding hexes of the same level. The directions are identified by the same numbering scheme as used for creating hex addresses. Thus, at each level, the hex direction 7 represents a null direction signifying no movement, and there are 6 equally spaced hex directions numbered 1 through 6. A level 0, hex direction 1 corresponds to north, but it undergoes a counterclockwise rotation of about 19 degrees for each higher level. Figures A-6 and A-7 illustrate the hex directions at levels 6 and 7.

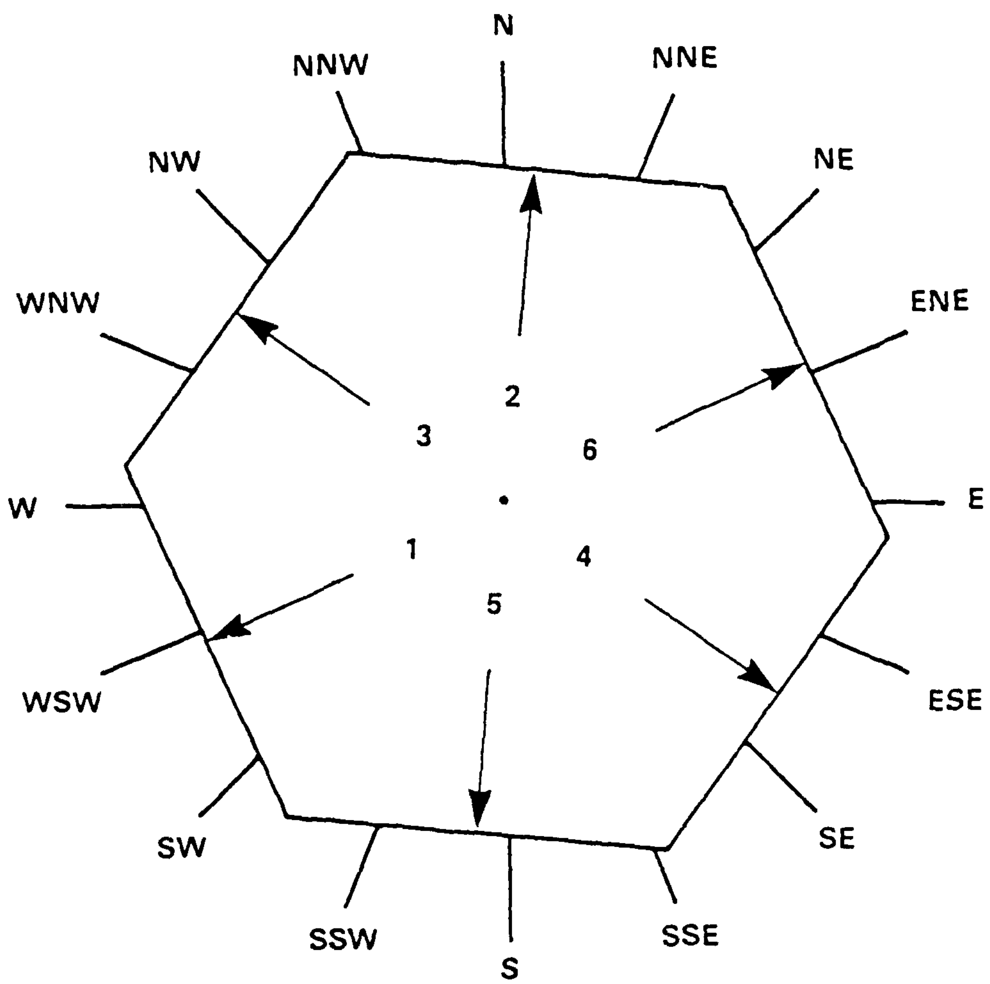


Figure A-6. Hex Directions At Level 6

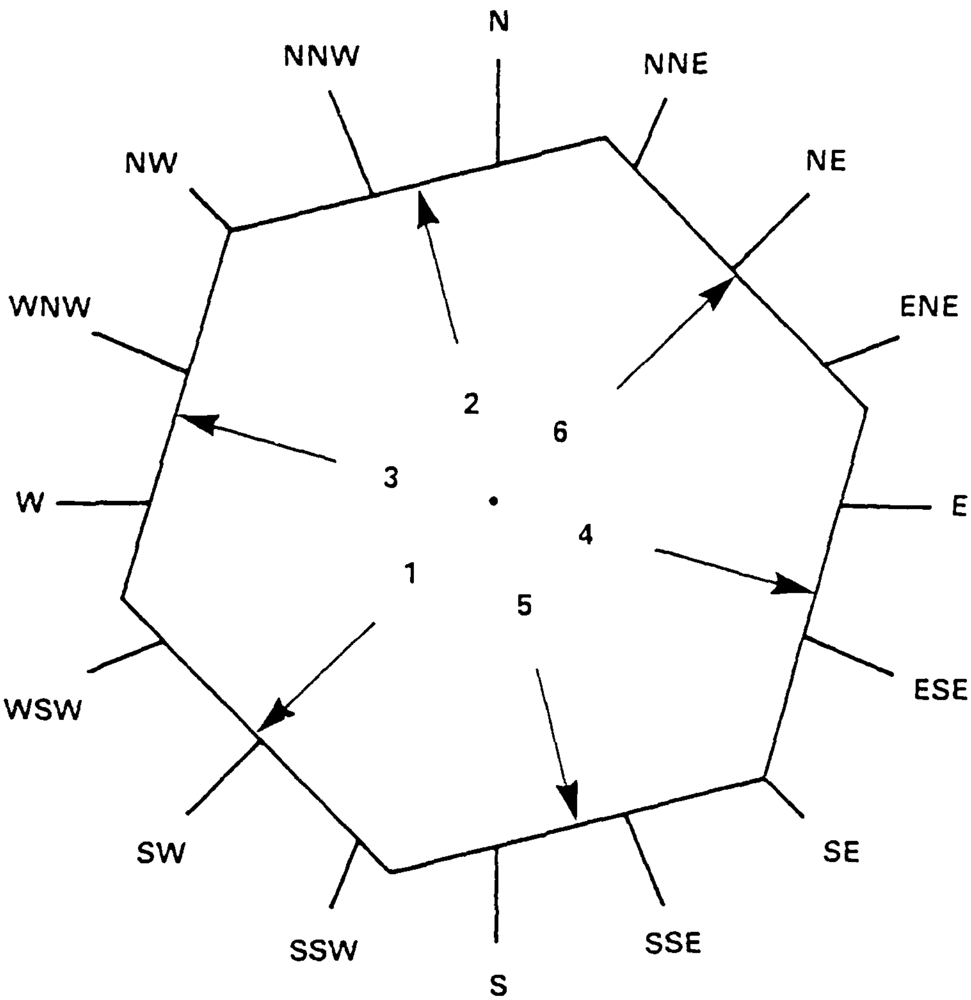


Figure A-7. Hex Directions At Level 7

APPENDIX B

MADEM DISPLAYED EVENTS

As events occur in the model a message will be printed to symbolize what is happening in the model. These event messages originate out of the subroutines. The variable numbers that are printed out in the message are denoted here by *NO.

The following is a list of the event messages and the subroutines associated with it. In the list below, the Source column shows the initiator of the event and is the key to the format of the event message print out. The events are printed in three columns: the first column is the Red, the second is the CRC/AB and the third is the BOC/BTRY.

Subroutine	Source	Message
AB2CRC	CRC/AB	CRC *NO ACKS LAUNCH OF INT *NO
	CRC/AB	CRC *NO ACKS LANDING OF INT *NO
ABSEE	CRC/AB	A/B *NO ACKS LANDING REQUEST FROM INT *NO
	CRC/AB	A/B *NO ACKS REQUEST FOR INTERCEPTORS BY *NO
ACCEPT	BOC/BTRY	UNIT *NO PLACES FLIGHT *NO ON FOQ
	BOC/BTRY	UNIT *NO RECEIVES ORDER TO ENGAGE FLIGHT *NO WITH *NO FIRE UNITS
AIRTHNK	RED	FLT *NO TYPE * NO ENGAGES *NO
	CRC/AB	INT *NO ENGAGE *NO RELEASING *NO
ALLOBAT	BOC/BTRY	BTN *NO ASSIGNING BATTERY *NO *NO (*NO) UNITS OF COVERAGE ON FLIGHT *NO
	BOC/BTRY	BTN *NO PLACES FLIGHT *NO ON PDIL

Subroutine	Source	Message
ALLOFU	BOC/BTRY	FIRE UNIT *NO OF BTRY *NO ASSIGNED TO FLIGHT *NO
ALLOPAT	BOC/BTRY	BTRY *NO TAKES ENG *NO (*NO) AGAINST FLT *NO
AMMOCHK	BOC/BTRY	BATTERY *NO: FIREUNIT *NO EMPTY
ATKASES	RED	FLT *NO DESTROYS TGT *NO TYPE *NO
	RED	FLT *NO REPORTS *NO TYPE AND HAS *NO DAMAGE
	RED	FLT *NO WILL BE SHOT FOR MISSING *NO TYPE *NO
BNCONHD	BOC/BTRY	BTN *NO PONDERS HEADING CHANGE BY FLIGHT *NO
BNCONTC	BOC/BTRY	BTN *NO PLACES FLIGHT *NO ON PDIL
BNNOTRD	BOC/BTRY	BTN *NO NOW IMPOTENT
BNPONBB	BOC/BTRY	BTN *NO WELCOMES ABOARD BTRY
BNPONBD	BOC/BTRY	BTN *NO MOURNS THE UNTIMELY DEATH OF BATTERY (*NO)
BNPONFA	BOC/BTRY	BTN *NO SAVORS THE DEATH OF *NO A/C IN FLIGHT *NO
BNPONFD	BOC/BTRY	BTN *NO CELEBRATES TOTAL ANNIHILATION OF FLIGHT *NO

Subroutine	Source	Message
BOCTINK	BOC/BTRY	BTN *NO GIVES UP ON FLIGHT *NO
BTNASIN	CRC/AB	CRC *NO ASSIGNS *NO TO BTN *NO
BTN2CRC	CRC/AB	CRC *NO ACKS RLSE OF TGT *NO BY BTN *NO
	CRC/AB	CRC *NO ACKS DEATH APT ON *NO BY BTN *NO
	CRC/AB	CRC *NO ACKS LOSS OF TGT TRK *NO BY BTN *NO
BTRYTNK	BOC/BTRY	BATTERY *NO GIVES UP ON FLIGHT *NO
	BOC/BTRY	BTRY *NO LOSES TRACK *NO (MASK = *NO)
BYALCOV	BOC/BTRY	BTRY *NO NOW TO COVER FLIGHT *NO WITH *NO FIRE UNITS
BYCMDPR	BOC/BTRY	BTRY *NO RELEIVES CEASE ORDER FOR FLIGHT *NO
BYCONHD	BOC/BTRY	BATTERY *NO PONDERS HEADING CHANGE BY FLIGHT *NO
BYNOTRD	BOC/BTRY	BATTERY *NO AWAITING RELOAD
BYPONRL	BOC/BTRY	BTRY *NO: FIRE UNIT *NO LOADED *NO TYPE *NO MISSILES
BYPONRS	BOC/BTRY	BTRY *NO RESUPPLIED -- *NO MISSLES
BYPONTM	BOC/BTRY	FLIGHT *NO TRACKED BY BATTERY *NO
CANCALO	BOC/BTRY	FIRE UNIT *NO OF BTRY *NO CEASES FIRE ON FLIGHT *NO
	BOC/BTRY	BTRY *NO CEASES ONE ENGAGEMENT OF FLT *NO (*NO)

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MODULAR AIR DEFENSE EFFECTIVENESS MODEL, PROGRAM DOCUMENTATION --ETC(U)
JAN 80 M FILTEAU, B MACALEER, J T HAWKINS   DNA001-79-C-0203
UNCLASSIFIED BDM/W-79-646-TR-VOL-1   DNA-5594F-1   NL

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Subroutine	Source	Message
CHKCOV	RED	POSSIBILITY --- *NO
COMMAND	RED	FLT *NO TYPE *NO DIVES TO *NO METERS
	RED	FLT *NO TYPE *NO CLIMBS TO *NO METERS
	RED	FLT *NO TYPE *NO AT RENDEZVOUS POINT
	RED	FLT *NO TYPE *NO STRT GND ATK ORB IN *NO
	RED	FLT *NO TYPE *NO REQUEST LANDING AT *NO
	RED	FLT *NO TYPE *NO HEADS FOR HEX *NO
CRC2INT	CRC/AB	INT *NO ACKS RTN TO A/B ORDR FRM CRC *NO
	CRC/AB	INT *NO ACCEPTS TARGET *NO
	CRC/AB	INT *NO REJECTS ASSIGNMENT OF TARGET *NO BY CRC *NO
	CRC/AB	INT *NO ACKS NEW INTERCEPT VECTOR
	CRC/AB	INT *NO ACKS BREAKOFF MSG FOR TARGET *NO
CRCKIL	CRC/AB	CRC *NO PONDERS DEATH OF *NO
	CRC/AB	CRC *NO PONDERS DEATH OF INT *NO
	CRC/AB	CRC *NO MARKS TGT *NO UNASSIGNED
CRCEVNT	CRC/AB	CRC *NO DETECTS DEATH OF *NO
	CRC/AB	CRC *NO ACQUIRES FLT *NO
	CRC/AB	CRC *NO LOSES FLT *NO
CRCTRAK	CRC/AB	CRC *NO SCRAMBLES INTERCEPTORS AT ALL A/B
	CRC/AB	CRC *NO CORRECTS MISID OF *NO
DECRALO	BOC/BTRY	BTN *NO ORDERS BTRY *NO TO REDUCE
DESTROY	RED	XXXXXXXXXXXXXXXXXX UNIT *NO IS DEAD XXXXXXXXXXXXX

Subroutine	Source	Message
DETECT	BOC/BTRY	UNIT *NO NOW SEES *NO
	BOC/BTRY	UNIT *NO MASKED FROM *NO
	BOC/BTRY	UNIT *NO LOSES SIGHT OF *NO
DOGFIGHT	CRC/AB	INT *NO FIRES ON *NO
	RED	FLT *NO TYPE *NO RELEASES A/G ORD
	RED	*NO HAS *NO A/C REMAINING OUT OF *NO
	RED	FLT *NO BLOWS INT *NO AWAY
	CRC/AB	INT *NO BLOWS FLT *NO AWAY
DOGTHNK	RED	FLT *NO TYPE *NO OUT OF A/A AMMO
	CRC/AB	INT *NO OUT OF AMMO
ENGAGE	BOC/BTRY	FIRE UNIT *NO OF BTRY *NO LOCKED ON FLIGHT *NO
	BOC/BTRY	FIRE UNT *NO OF BTRY *NO FIRES ON FLIGHT (NO (*NO)
FILERUP	BOC/BTRY	UNIT *NO MISREADS LOYALTY OF FLT *NO
FLY	RED	FLT *NO TYPE *NO CRASHS DUE TO FUEL
	CRC/AB	INT *NO CRASHES DUE TO LOW FUEL
FLYSEE	CRC/AB	INT *NO DETECTS ASSIGNED TARGET *NO
	RED	FLT *NO TYPE *NO DETECTS DEATH OF AIR TGT *NO
FUELCK	CRC/AB	INT *NO HEADS FOR A/B DUE TO LOW FUEL
	RED	FLT *NO TYPE *NO GOES HOME DUE TO LOW FUEL

Subroutine	Source	Message
GNDLOOK	RED	FLT *NO DETECTS GND TGT *NO
	RED	FLT *NO OVERLOOKS GND TGT *NO IN *NO
	RED	FLT *NO DISCOVERS TGT *NO NOT IN *NO
	RED	FLT *NO TYPE *NO ABORTS GROUND ATTACK
GOGETEM	CRC/AB	A/B *NO LAUNCHS INTRCPTR *NO
INT2CRC	CRC/AB	CRC *NO ACKS INT *NO AVAIL - DEAD TARGET *NO
	CRC/AB	CRC *NO ACKS INT *NO AWAITING ORDERS
	CRC/AB	CRC *NO ACKS ACQUISITION BY INT *NO OF TARGET *NO
	CRC/AB	CRC *NO ACKS NONAVAIL MSG FRM INT *NO
	CRC/AB	CRC *NO ACKS MISID OF TGT *NO
	CRC/AB	CRC *NO ACKS REFUSAL OF TGT *NO BY INT *NO
INTASIN	CRC/AB	CRC *NO ASSIGNS *NO AGAINST *NO
	CRC/AB	CRC *NO SCRAMBLES INTERCEPTRS AT A/B *NO
INTFIND	RED	FLIGHT *NO DETECTS ASSIGNED TGT *NO AT TIME *NO
INTRFLY	CRC/AB	INT *NO REQUESTS LANDING FROM A/B *NO
	CRC/AB	INT *NO RETURNS TO A/B *NO FOR CAP
NEWMOVE	CRC/AB	CRC *NO MISTAKES IFF OF *NO SIDE *NO
NUKBLND	RED	+++++++++++++++ UNIT *NO COMMO IS DEAD +++++
READIL	BOC/BTRY	BTN *NO RETURNING FLIGHT *NO TO ADIL

Subroutine	Source	Message
RONDSEE	RED	RENDEVOUS COMPLETE - CORRIDOR HEX *NO
SAMATON	BOC/BTRY	UNIT *NO GOES AUTONOMOUS
SDIGEST	BOC/BTRY	UNIT *NO DIGESTS INFO ON FLIGHT *NO
	BOC/BTRY	UNIT *NO MISREADS LOYALTY OF FLT *NO
SHRKILL	CRC/AB	FLT *NO TYPE *NO LOSES 1 A/C TO SHORADS AT *NO
	RED	FLT *NO TYPE *NO KILLED BY SHORADS AT HEX
TOADIL	BOC/BTRY	UNIT *NO MOVING FLIGHT *NO
TOWER	RED	RED A/B * NO LAUNCHS FLT *NO
	RED	RED A/B *NO LANDS FLT *NO
	CRC/AB	A/B *NO LANDS INT *NO
TRYSHOT	BOC/BTRY	BTRY *NO HAS NO AMMO USEABLE AGAINST FLT *NO
	BOC/BTRY	BTRY *NO DISCOVERS FLIGHT *NO OUT OF ALTITUDE LIMITS
UMPIRE	BOC/BTRY	FIRE UNIT *NO OF BTRY *NO VS FLIGHT *NO -- KILL ###
YANK	RED	BLOOOODDDYYY MURDER

APPENDIX C

COMMAND AND CONTROL MESSAGE LIST

Communication events are the sending of messages from one player to another. These messages originate in the subroutines. There is a code number associated with each message type.

The following is a list of the messages and the subroutines they occur in. The message is not printed out in this form, it is the interpretation of it. For a list of the event messages printed as output see Appendix B.

Event No.	Code	Subroutine	Message
25650001	1320	AIRTHNK	Schedule msg. to live CRC of availability
25690001	1320	AIRTHNK	Report from interceptor to CRC that interceptor is goint to engage a target of opportunity
25690001	2831	ALLOBAT	Order from BOC to BTRY to attempt to engage a particular flight
25690001	2834	ALLOBAT	Order from BOC to BTRY increasing assigned coverage level against a particular flight
25340001	2751	AMMOCK	Report from BTRY to BOC that assigned flight can no longer be engaged due to lack of appropriate type of ammo
25690001	1500	BADMOVE	Schedule breakoff message to interceptor

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Event No.	Code	Subroutine	Message
25690000	1520	BADMOVE	Update from CRC to interceptor on course of assigned flight
25690001	2835	BNCONHD	Update from BOC to BTRY on course of assigned flight
25690001	1600	BNCONLS	Report from BOC to CRC that assigned flight has been lost to sight
25690001	1600	BNCMDPR	Report from BOC to CRC indicating assignment cannot be accepted because no assets ready for action
25690001	2761	BNLALLE	Report from BOC to CRC, or from BTRY to BOC, indicating no projected opportunity to engage assigned flight
25690001	2832	BNPONEP	Order to BTRY to cease fire on a particular flight
25690001	1600	BOCTINK	Report from BOC to CRC that assigned flight was not sighted
25120001	2731	BTNASIN	Order from CRC to BOC to attempt to engage a particular flight
25690001	2762	BTRYTNK	Report from BTRY to BOC that assigned flight was not sighted as expected

Event No.	Code	Subroutine	Message
25690001	2762	BYCONLS	Report from BTRY to BOC that assigned flight has been lost to sight
25690001	2762	BYCONTL	Report from BTRY to BOC that assigned flight has changed course
25690001	2761	BYHEDUP	Report from BTRY to BOC that BTRY no longer has a projected opportunity to engage an assigned flight
25690001	2762	BYNWTRK	Report from BTRY to BOC that assigned flight was changed course
25690001	2780	BYPONER	Report from BTRY to BOC on attrition of assigned flight
25690001	2790	BYPONFD	Report from BTRY to BOC on total destruction of flight
25690001	2752	BYPONRL	Report from BTRY to BOC on ammo reload
25390001	1984	COMMAND	Landing request from aircraft to airbase
25690001	1310	CRC2INT	Report from interceptor to CRC that interceptor is available for assignment
25650001	1330	CRC2INT	Schedule msg to CRC can't accept assignment
25650001	1312	CRCTRAK	Order from CRC to airbase to scramble interceptors

Event No.	Code	Subroutine	Message
25690001	2832	DECRALO	Order from BOC to BTRY to cease fire on a particular flight
25690001	2834	DECRALO	Order from BOC to BTRY decreasing assigned coverage level against a particular flight
25690001	1340	DOGTHNK	Report from interceptor to CRC that interceptor is out of air-to-air ammo and is returning to base
25690001	2832	DROPPOS	Order from BOC to BTRY to cease fire on a particular flight
25690001	2832	DROPPS2	Order from BOC to BTRY to cease fire on a particular flight
25650001	1300	FLYSEE	Report from interceptor to CRC that current target is destroyed, and interceptor is available for another assignment
25390001	1340	FUELCHK	Report from interceptor to CRC that interceptor is returning to base for fuel
25120001	1312	INTASIN	Request interceptor launch
25120001	1510	INTASIN	Message to interceptor of assignment

Event No.	Code	Subroutine	Message
25620001	1330	INTFIND	Message to CRC reporting direction
25390001	1310	INTERFLY	Request orders from CRC
25390001	1984	INTRFLY	Landing request from interceptor to airbase

APPENDIX D

THE AFWL SYSTEM

MADEM uses either of 2 computers at AFWL, the Y mainframe (MFY) or the X mainframe (MFX). Both are CDC Cyber 176 machines. We generally run on MFY since our remote terminal has a direct line there, but we can run on either. It is possible to use a dial up terminal for either batch or interactive service using the following phone numbers.

BAUD RATE	MFY	MFX
300	505-264-2082(3)	505-842-5162 (17)
300	--	505-842-9980 (10)
300	--	505-264-5875 (3)
300	--	505-264-9861 (3)
1200	505-264-5840 (3)	505-264-5705 (3)
4800	505-264-7812 (3)	--
4800	505-842-6392 (2)	505-842-6391 (4)
4800	--	505-842-5711 (6)

The number in parenthesis is the number of lines on that rotary. MADEM cannot run on MFB because of the extended core requirements of MADEM.

1. AFWL Operating System

AFWL runs on the NOS/BE 1.2 operating system. The correct manual for this operating system is the CDC manual 60493800.

Intercom 4.1 is the operating system that interfaces remote terminals (batch or interactive) with the mainframes. Ths manual for this is the CDC manual 60494600.

2. Using AFWL from BDM - Washington

We have a data 100 remote batch terminal that has a direct line (4800 BAUD) to AFWL's MFY. We can also dial up from another terminal, but we generally use the Data 100.

a. Using the Data 100

To bring up the Data 100:

1. Load Emulator - Read in "DATA 100" cards by pressing "HALT", then "LOAD". After cards have been read press "RUN".
2. Press XMIT button - XMIT light on is for 029 keypunch.
3. Wait for "DATA LINK" light.
4. Before entering each command, press Control-A.
5. Type "LOGIN, SGCBDM, WDNA14V6, SUP"
6. Wait for "COMMAND" message.
7. Type "C".

To Enter Cards:

1. Load cards.
2. Press START
3. Type "R" when reader stops.

To turn on line printer type "ON,LP".

3. AFWL JCL Notes

a. AFWL Job Card

The first card in a JCL deck is a job card.

Example: MADEM, ST176, T40, IO37, P66.

MADEM - can be any name, first five characters used as first five characters of seven character job name.

ST176 - Tells it to run on either Cyber 176 (MFY or MFX). Can also use STMFX of STMFY to run on a particular machine.

T40 - CPU time limit in octal seconds.

IO37 - IO time limit in octal seconds.

P66 - Request for 66 priority. The highest priority allowed. The priority is dependent on IO and CPU time requested.

P66 IO+CPU is less than 100 octal

P60 IO+CPU is less than 400 octal

P50 IO+CPU is less than 1,000 octal

P40 none

P30 CP is less than 1000B

P20 CP is less than 2000B

P10 CP is less than 4000B

b. AFWL Account Card

The second card in a JCL deck is the account card.

Example: ACCOUNT MADEM, XXXXXXXX-ZZZ, BDM,703-821-4223.

ACCOUNT - Card identifier

MADEM - means nothing, can be any name.

XXXXXXXX account ID

ZZZ - account password.

BDM - not needed, but it identifies us.

703-821-4223 - not needed, but enables us to be reached by this phone number in case a problem occurs.

c. End-of-Record Cards

To separate the JCL from the INPUT File, or to separate two INPUT Files, use an End-of-Record (EOR) card. The EOR card is a multi-punch 7/8/9 in column one. When submitting jobs interactively, the system will interpret *EOR as an EOR card. In some of our JCL examples in this manual, an EOR card is represented by a '&' in column one.

d. End-of-information Cards

At the end of an entire input stream (that is, JCL and any INPUT Files) use an End-of-Information (EOI) card. The EOI card is a multi-punch 6/7/8/9 in column one. When submitting jobs interactively, the system will interpret *EOI as an EOI card. In some of the JCL examples in this manual, the EOI card is represented by a '#' in column one.

4. Large Permanent Files at AFWL

Any permanent file larger than 35 RB's (1960 PRU's) will be routinely purged at AFWL.

1 PRU = 64 words

1 RB = 56 PRU's (3,584 words)

35 RB's = 125,440 words

Theoretically, one can have a large perm file saved at AFWL if it is approved by Airman Vickers. To have a perm file over 35 RB's saved at AFWL write to:

Airman Richard Vickers
AFWL/ADPO
Kirtland AFB
New Mexico 87117
(505-264-7984)

With the following information:

1. Justification for the large file.
2. How long the file is to be saved.
3. The name of the file.
4. Your account ID.
5. The cycle numbers of that file to be protected.

APPENDIX E

VALID PLAYERS AND TARGETS

MADEM is a simulation that interacts with entities within the model. These entities are in two catagories: active players and passive targets. The valid players are the ones that can be acted upon or react. A passive target can only be acted upon, such as targets that can not defend themselves. The following is a list of each category and the internal code used to represent it in the model.

Active Players

Name	Code
AIRBASE	220
ATAF	128
AWACS	132
CRC	130
HAWKBOC	150
HAWKBTRY	170
HERCBOC	160
HERCBTRY	180
PATBOC	155
PATBTRY	175
SOC	153

Aircraft Flights

Name	Code
BLUE INTERCEPTORS	401-419
RED FIGHTERS	420-439
RED FIGHTER/BOMBER	440-459
RED BOMBERS	460-478

Passive Targets

Name	Code
ASP	87
BRIDGE	39
CLVBTRY	94
CORPCP	95
DEPOS	40
DIVCP	92
HJ	34
LANCE	86
PERSHING	83
POL	84
RESERVES	88
SASP	210
TAB	158
TRAINS	89
VIIIBTRY	90

Special case

Name	Code
SHORAD	1
COLUMN/ROW TOTAL	9999

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